QUASAR

User Manual

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Abstract: This document is the user manual for the QUASAR motor control software. It describes all features and provides extensive information about the setup and system tuning.

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Change management

Version	*Page / Section*	*Description*	*Date*	*Name*
1.0		New version	16.11.2011	CAE
1.1		Remarks added, pictures and tables replaced	15.02.2012	CAE
1.2	All	Applied new template	15.03.2012	CDA
1.3	All	Merged content of different documents	31.07.2012	CDA
		Adapted for new parameter tree		
1.4	All	ACIM field weakening updated	11.09.2012	RGA
		ACIM control diagram updated		
		Brushless DC-Motor removed		

Table 1 - Change management

Release

Version	*Description*	*Date*	*Name*
2.0	Release for QUASAR V1.03.1	12.09.2012	CDA

Table 2 – Release

1 Disclaimer

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2 Introduction

QUASAR is the motor control software designed and implemented to run on SEMIKRON SKAI high voltage (HV) and low voltage (LV) inverters. It can be used for traction applications with Permanent Magnet Synchronous Machines (PSM), Interior mounted Permanent Magnet Synchronous Machines (IPMSM) or Alternating Current Induction Machines (ACIM).

QUASAR supports a wide range of system setup functions. It provides a set of parameters that allows customizing the motor control software. Thus correct configuration of those parameters is essential.

This document gives an overview of the features supported by QUASAR and defines the steps needed to get the fully configured QUASAR software running.

2.1 Purpose

This document contains information for experienced engineers to work with the QUASAR motor control software. With the given step by step instructions QUASAR can be set up and tuned to be used in a system with a SKAI inverter.

Information about the SKAI hardware, cabling and system design is not part of this document.

The document is split into three main parts:

Product Features: The first part provides general information about the product features.

Setup Guide: The second part is a step by step setup and configuration tutorial. This part includes all chapters starting from chapter 4.

Parameter Description: The last part in the Appendix of the document is a detailed description of all parameters available in the system.

2.2 Document Conventions

The following section provides information about how to use this document.

2.2.1 Parameters

Throughout the document parameters are referenced with their names and a unique parameter number which actually represents the CANopen object index.

Example: *Motor type [2119]*

Each reference of a parameter is linked with the related parameter description in the appendix. Click on the link to jump to the respective section.

After following a link you can navigate back to the last position in the document by pressing <ALT + ←>.

2.2.2 Hints and Important Information

The following graphical notations are used to inform about hints and important notes.

Gives additional useful information or hints how to improve or simplify a specific task.

Notifies about important issues or commonly made mistakes and how to omit them.

2.3 Intended Audience

This manual is written to be understood by electrical engineers with know-how in electric machines, inverters and the related sensors.

For advanced tuning steps, advanced know-how in motor control techniques will be needed to proceed with the given information.

2.4 Terms and Abbreviations

Term	*Description*
ACIM	Alternating current induction motor
Base speed	Motor speed where field weakening starts (at rated DC link voltage)
BOT	Bottom IGBT
CAN	Controller Area Network
CANopen	Communication protocol for CAN bus
DUT	Device under test (tuning)
ECU	Engine control unit (or Electronic Control Unit)
Encoder	Term used for rotor position sensing devices. This applies for all types of position sensing devices.
FOC	Field Oriented Control (vector control)
FW	Field weakening
HW	Hardware
ID	Identifier (e.g. CANopen node ID)
IPM	Interior permanent magnet synchronous motor
LCU	Logic Control Unit
MC	Motor Control, the part in QUASAR controlling the motor
Motor	In this document “motor” is used as a general term. When referencing to “motor”, an electric machine in generator or motor mode or any other load or source is meant.
NLSF	Non-linear state feedback (Cross-coupling decoupling)
NMT	Network Management (CANopen)
PC	Personal Computer
PCB	Printed Circuit Board
PDA	Process Data Object (CANopen)
PSM	Surface-mount permanent magnet synchronous motor
RTR	Remote Transmit Request (CANopen)
Rx	Receive (CAN messages)
SDO	Service Data Object (CANopen)
SKAI	SEMIKRON (SK) advanced integration, 3 phase inverter with DSP controller
SKAI HV	High voltage SKAI
SKAI LV	Low voltage SKAI
SW	Software
SYNC	Synchronisation Object (CANopen)
TOP	Top IGBT
Tx	Transmit (CAN messages)
VCU	Vehicle control unit

Table 3 – Terms and Abbreviations

2.5 References

Ref.	*Title*	*Description*	*Author*
[1]	QUASAR CAN Protocol	CAN protocol definition for QUASAR ***0013_DO_QUASAR_CAN Protocol.pdf***	ALI
[2]	Q-Control User Manual	Detailed information about Q-Control ***0026_DO_Q-Control_User Manual.pdf***	CAE
[3]	Setup calculations	Excel file with useful calculations used during the setup process ***0043_DO_QUASAR_Setup Calculations.xlsx***	CDA
[4]	Technical explanation SKAI HV	SKAI2 HV 3-Phase IGBT Inverter System for e-Vehicle Applications	SEMIKRON

Table 4 – References

3 Product Features

3.1 System Overview

The QUASAR software together with the SKAI hardware combines to an integrated inverter system, which controls the machine and its sensors and other peripherals.

The system can be controlled over a CAN bus using the CANopen protocol. Q-Control is the tool to configure the inverter to work with the connected machines and sensors and is essential for testing and improving the motor control tuning.

In the final customer system an overlaying controller such as an Engine Control Unit (ECU) or a vehicle control unit (VCU) will command QUASAR and will take control over the complete system.

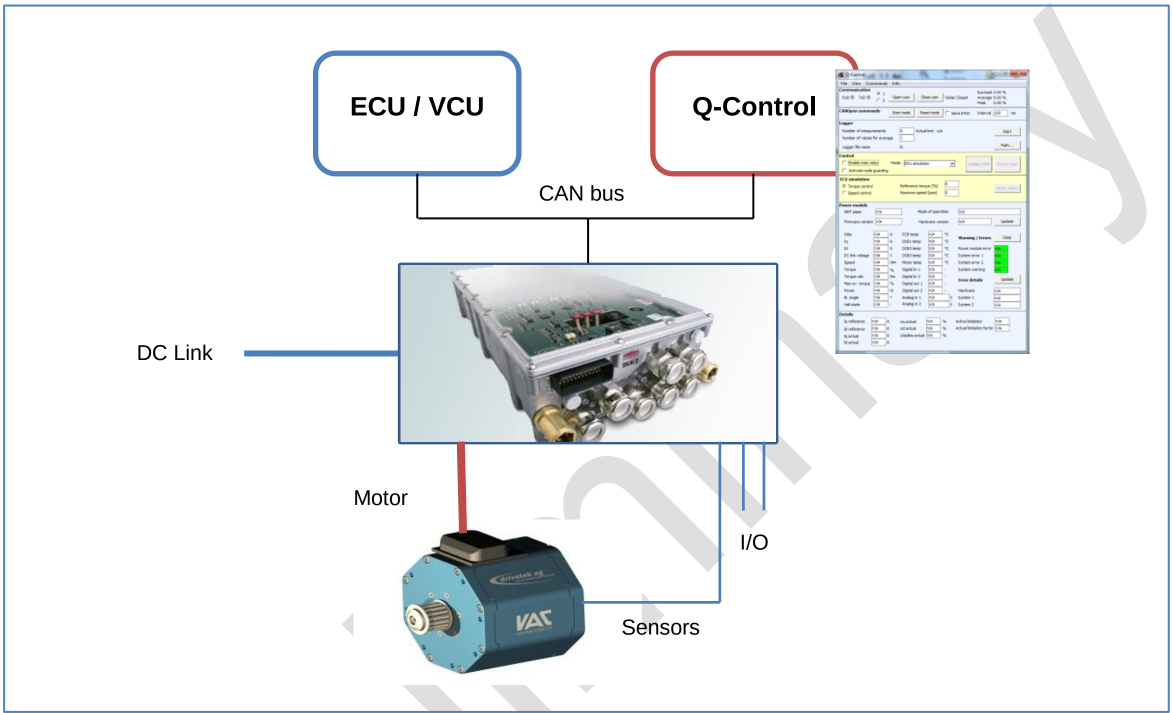


Figure 1 – System Overview

3.2 Supported SKAI Types

Currently QUASAR has only been tested and released for SKAI HV. Please contact local sales for the usage of SKAI LV.

QUASAR is designed to run on all available SKAI2 inverter types. For each base type all available options for auxiliary power supply and DC link voltage are supported.

- SKAI2 High Voltage: SKAI HV
- SKAI2 Low Voltage SINGLE SKAI LV single
- SKAI2 Low Voltage DUAL SKAI LV dual

Depending on the provided interface on the individual inverter type some features of QUASAR may not be available. Restrictions are indicated for the respective features in this document.

The following figures show a SKAI LV and a SKAI HV system.

Figure 2 – SKAI2 Low Voltage

Figure 3 – SKAI2 High Voltage

3.3 Motor Types

QUASAR implements vector control for the following motor types:

- Surface-Mounted Permanent Magnet Synchronous Motor (PSM)
- Interior Permanent Magnet Motor (IPM)
- AC Induction Motor (ACIM)

A wide range of parameters allows the tuning of the vector control for the customer's motor characteristic in order to reach best efficiency.

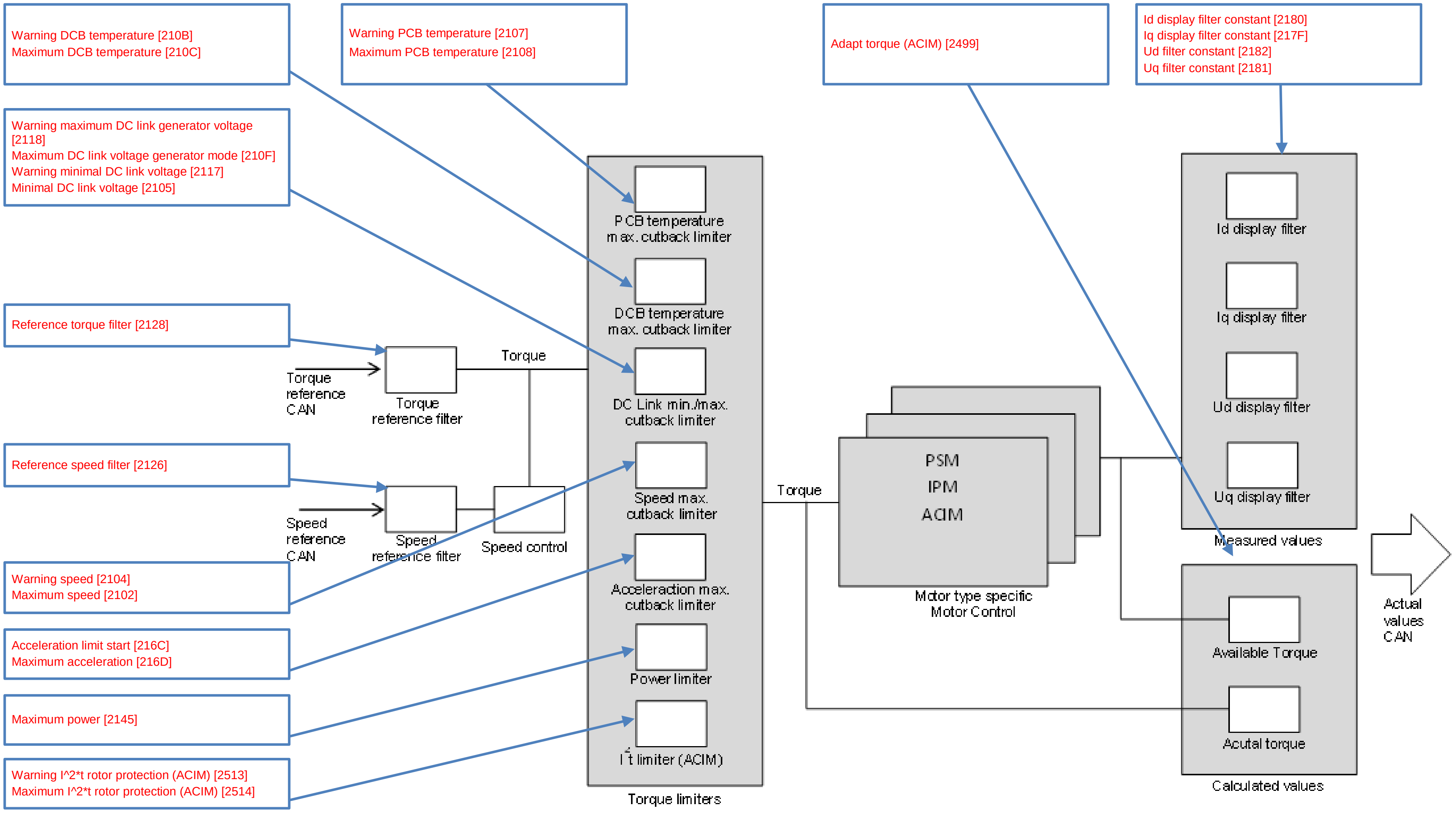
3.4 QUASAR Motor Control

The following chapters give an overview of the motor control implementation and the parameters used to tune it. Depending on the motor type a different set of parameters is needed.

The following notation is used for the parameters:

---- Parameter [Object]
---- Filter [Object]
---- Bit in the *Configuration vector control [2150]* parameter [flag value]
---- Bit in the *Configuration hardware [2140]* parameter [flag value]

3.4.1 General Motor control



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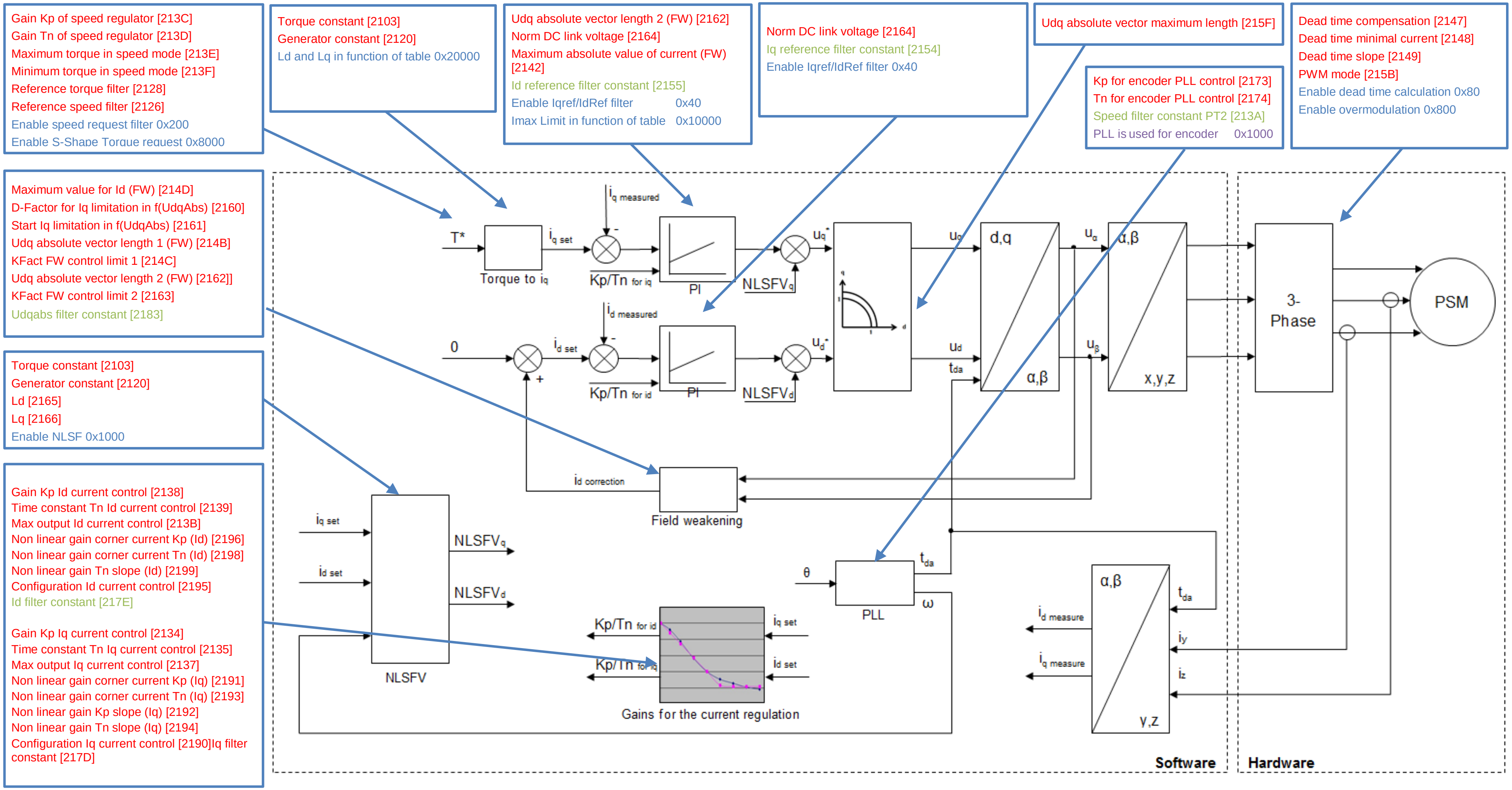
3.4.2 PSM Motor Control Overview



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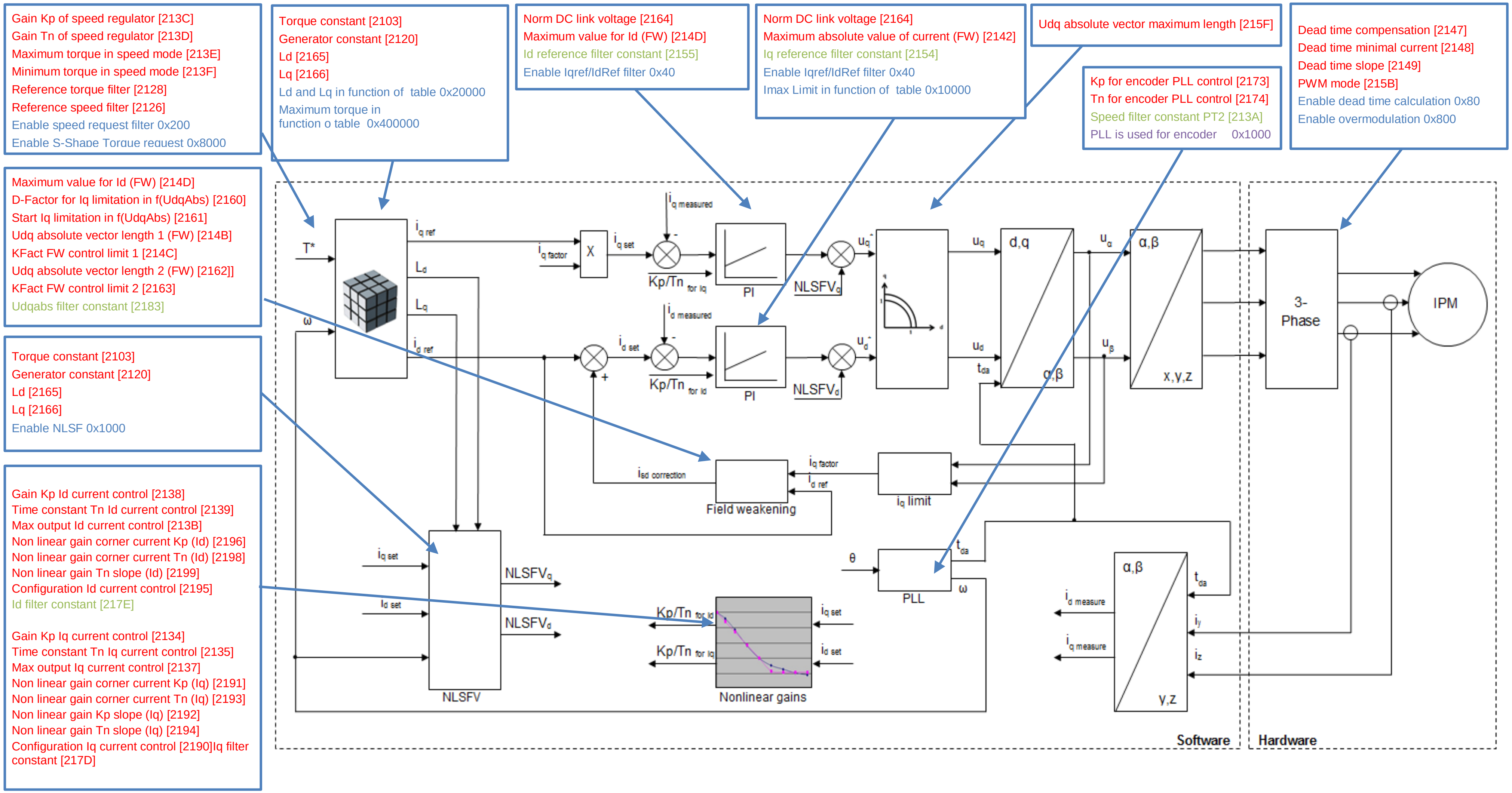
3.4.3 IPM Motor Control Overview



3.4.4 ACIM Motor Control Overview

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Maximum torque in speed mode [213E]
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Reference torque filter [2128]
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Enable S-Shape Torque request 0x8000

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Constant for Iq to flux [2500]
Coefficient 0 for Iq to flux [2490-1]
Coefficient 1 for Iq to flux [2490-2]
Coefficient 2 for Iq to flux [2490-3]
Adapt torque (ACIM) [2499]
Nominal motor torque (ACIM) [2501]
Pole pairs [2124]

Magnetizing current constant [2459-1]
Magnetizing current coefficient 0 [2459-2]
Magnetizing current coefficient 1 [2459-3]
Magnetizing current coefficient 2 [2459-4]

Nominal magnetizing inductance [2455]
Magnetizing inductance coefficient 0 [2457-1]
Magnetizing inductance coefficient 1 [2457-2]
Magnetizing inductance coefficient 2 [2457-3]

Maximum slip (ACIM) [248F]
Rotor resistance (ACIM) [2453]
Rotor leakage inductance (ACIM) [2454]
Flux filter for slip limiter [2493]
Udq_abs filter (ACIM) [2498]

Udq absolute vector maximum length [215F]

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KFact FW control limit 2 [2163]
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KFact FW control limit 1 [214C]
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Gain Kp Id current control [2138]
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Gain Kp Iq current control [2134]
Time constant Tn Iq current control [2135]
Max output Iq current control [2137]
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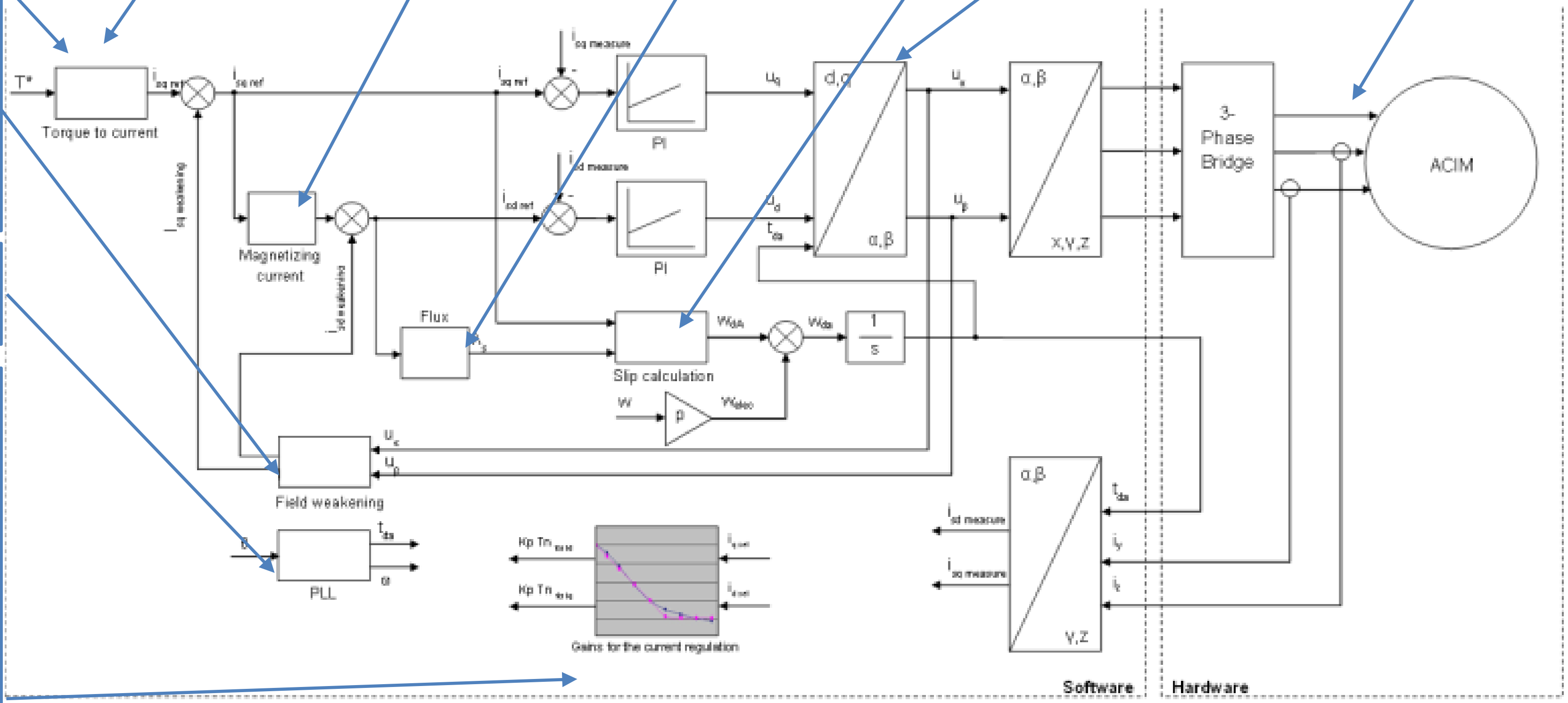
Non linear gain Kp slope (Iq) [2192]
Non linear gain Tn slope (Iq) [2194]
Configuration Iq current control [2190]Iq filter constant [217D]



3.5 Control Modes

QUASAR can operate in different modes. The mode can be selected by the ECU/VCU over the CANopen command interface.

Mode	*Reference and limit values [unit]*	*Motor*	*Generator*
Torque mode with symmetric limit	• Reference Torque [%] • Maximum speed [rpm]	x	-
Torque mode with asymmetric limit	• Reference Torque [%] • Speed [rpm] with high and low limit	x	-
Speed mode with symmetric limit	• Reference speed [rpm] • Maximum Torque [%]	x	x
Speed mode with asymmetric limit	• Reference speed [rpm] • Torque with high and low limit [%]	x	x

Table 5 – QUASAR Control Modes

In all control modes the respective limits can be changed during operation (PWM enabled). The commands to be used are described in [1]. Also switching between modes is allowed during operation.

The reference and limit values are validated by QUASAR. These checks include verification that low limits are lower than high limits. Further the values are limited to maximum values. If problems are detected values are corrected to fit the respective range and a warning is indicated.

In all modes the symmetric and asymmetric limiters are implemented as normal cutback limiters (see chapter 0).

3.5.1 Torque Control Mode

In torque control mode the reference torque is given in percent of maximum torque. The maximum torque is defined by the nominal torque (*Nominal motor torque (ACIM) [2501])* for ACIM motors and the maximum I_q current (*Maximum current motor [2100])* for PSM motors . The reference torque of IPM motors selects the required currents over tables.Depending on the mode of operation (limitation mode flag in Rx-PDO1, refer to [1]) either symmetric or asymmetric limits are used for speed limitation.

If torque control mode with symmetric speed limit is selected, the torque will be limited with a factor (p.u) in order to limit speed as shown in Figure 4.

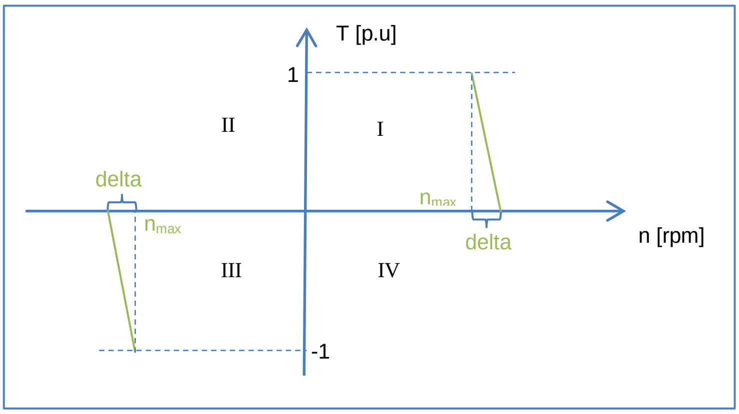


Figure 4 - Torque control mode with symmetric speed limit

When regenerating (see quadrants II and IV in Figure 4) the speed limiter is not active, because the torque would have to be increased in order to limit the speed, but the motor control shall never produce more torque than requested.

In torque control mode with asymmetric speed limit, a high and low speed limit can be defined. For example, the motor can be forced to accelerate in forward direction by setting the low limit to 0 [rpm] and the high limit to the maximum speed requested.

The speed limits only apply in motoring mode and will be ignored in generator mode. Therefore the following range for the limits applies.

- $n_{lim\_H} \geq 0$
- $n_{lim\_L} \leq 0$

The speed limiters are implemented as normal cutback limiters (see chapter 0). The start of the limitation is given by the limit. The slope of the cutback limiter is given by *Speed limit delta for slope [215A-1]*.

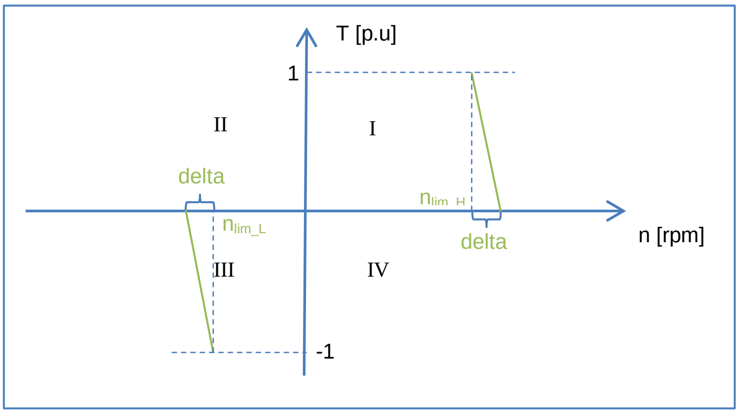


Figure 5 – Torque control mode with asymmetric speed limit

In the torque control mode the respective limits can be changed during operation (PWM enabled). The commands to be used are described in [1].

3.5.2 Speed Control Mode

Similar to the torque control mode, in speed control mode the command interface provides two limitation modes.

In speed control with symmetric torque limits, the given value of torque in RxPDPO1 (refer to [1]) is used as maximum value of the torque.

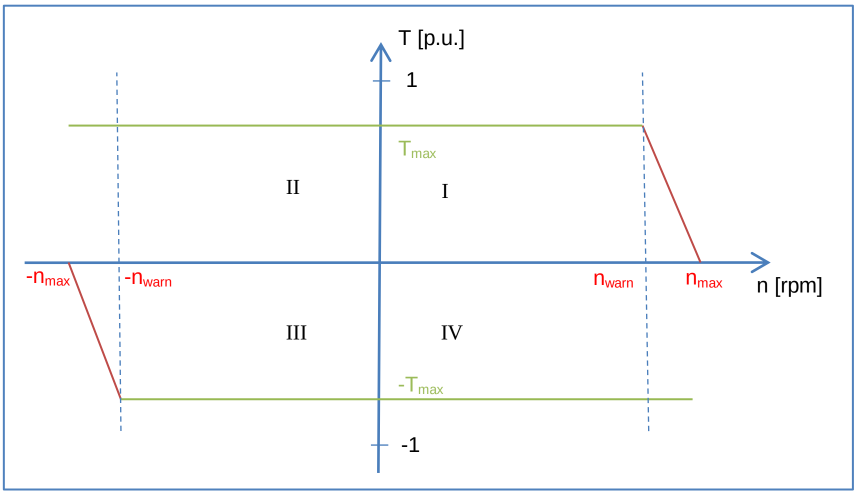


Figure 6 – Torque limiter in symmetric speed control

In addition to the torque limitation the speed cutback limiter see chapter 3.9.3.1 is applied to reduce motor speed to maximum allowed values.

The advantage of speed control with symmetric limits is that only one value has to be set for torque limitation. The drawback is that the ECU/VCU cannot influence the behavior in very dynamic situations. For example, if the vehicle has to overcome an obstacle it may need maximum torque (Tmax) for traction, but as soon as the obstacle has been overcome, the vehicle would accelerate. With symmetric limits the controller would now start braking with maximum torque (-Tmax), but this

time without load. This behavior can lead to undesired jerking. Therefore asymmetric limits were added.

In speed control mode with asymmetric torque limit, a high and low torque limit can be defined in Rx-PDO2 (refer to [1]). This allows the ECU/VCU to control the drive characteristics in a suitable manner for the current situation. For example, maximum acceleration can be allowed while the braking torque is limited.

The torque limits can be freely chosen, the only rule that applies is that the upper limit (T_{lim_H}) has to be greater than the lower limit (T_{lim_L}). Both limits can be positive or negative.

If low and high limits have the same sign or do not differ enough, the controller may not be able to regulate all operating points. Therefore the limits must be set with caution and should normally have different signs.

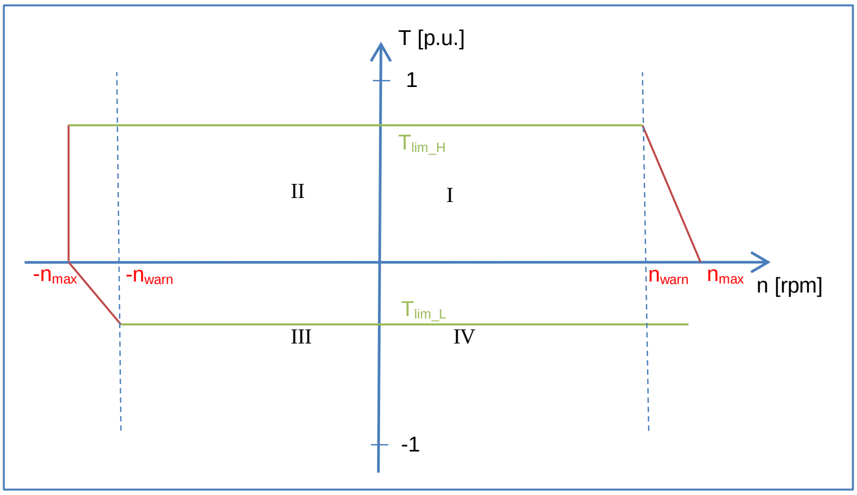


Figure 7 – Torque limiter in asymmetric speed control

In speed control mode the respective limits can be changed during operation (PWM enabled). The commands to be used are described in [1].

3.6 Test Modes

QUASAR provides some test modes that may be useful while tuning motors. Test modes can be selected over the command interface described in [1].

Test Mode	***Description***
D-axis and q-axis currents	Apply specific d-axis and q-axis currents. Can be used to make current steps for the current controller tuning after the angle offset has been adjusted.
Open rotating test mode (voltage)	Apply a fixed voltage magnitude with a specific frequency Important: Current is not limited.
Stationary vector	Apply a fixed voltage magnitude with a specific angle.
Closed loop rotating (current)	Apply a fixed current with a specific frequency.

Table 6 – QUASAR test modes

Test modes must only be used within safe environment for test purposes. Some control and safety mechanisms can be disabled.

All test functions are provided without any warranty.

3.7 Motor Control Features

QUASAR supports a wide range of state of the art motor control features to reach best efficiency for all supported motor types.

Vector Control Features	Parameter	Motor Type			
		PSM	IPM	ACIM	BLDC
Third harmonic injection	Always active	x	x	x	-
Overmodulation I	*Configuration vector control [2150]*	x	x	x	-
Non linear state feedback (NLSF)	*Configuration vector control [2150]*	x	x	-	-
Field weakening	*Configuration vector control [2150]*	x	x	x	
Dead time compensation	*Dead time compensation*	x	x	x	
PWM modes (SVM, DPWMA, DPWMB)	*PWM mode [215B]*	x	x	x	x

Table 7 – Motor control feature overview

3.7.1 Third Harmonic Injection

The maximum modulation index of a three-phase inverter PWM system can be increased by including a common mode third harmonic term into the target reference waveform of each phase leg.

With the standard method it is possible to obtain a gain on the fundamental waveform of +11% (red curve). QUASAR implements further optimizations to obtain a gain of +15% (blue curve).

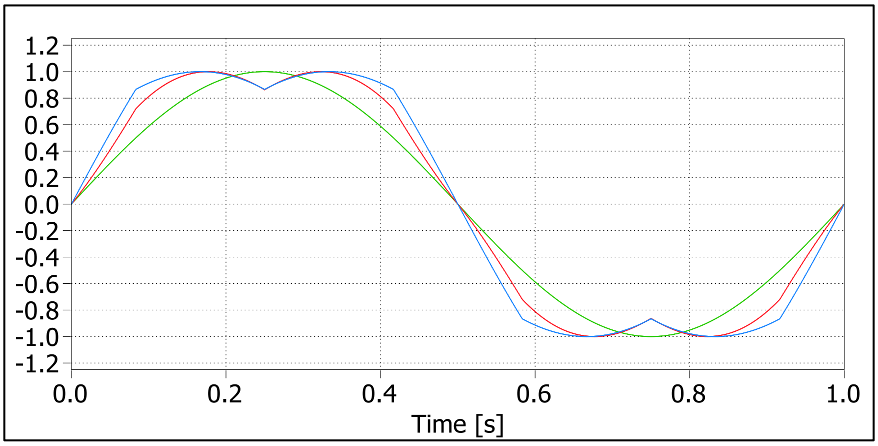


Figure 8 – Third harmonic injection: Basic solution (red), optimized QUASAR solution (blue)

Figure 9 shows the resulting waveform after adding third harmonic injection on each phase leg and the waveform measured between two phases.

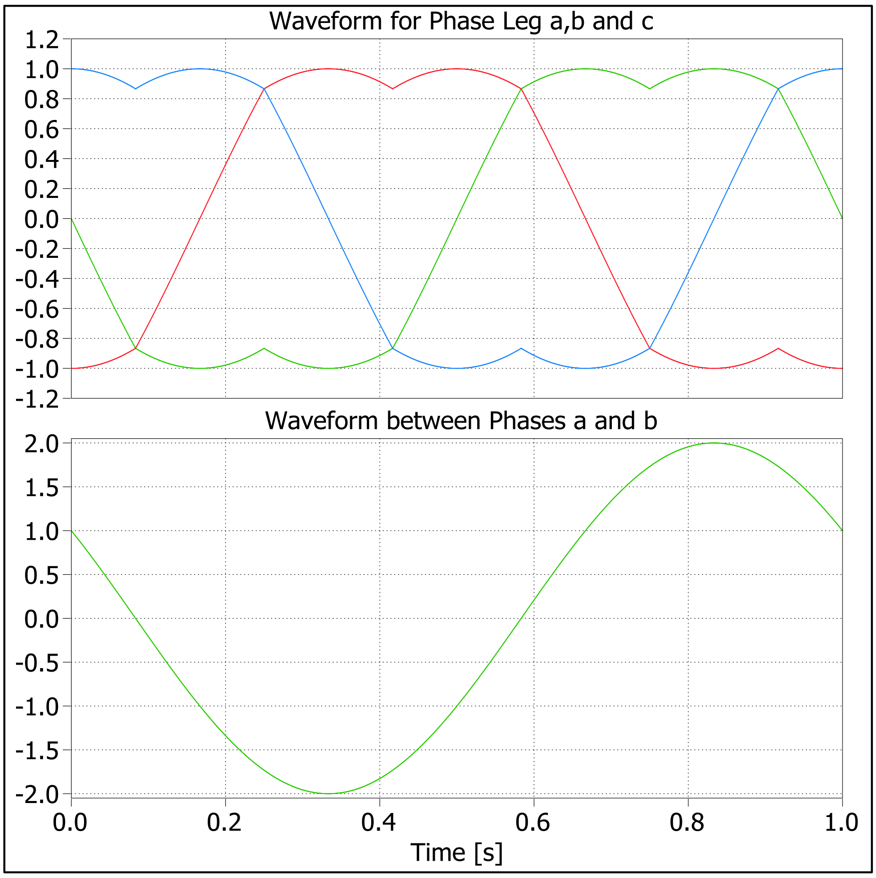


Figure 9 – Third harmonic injection: Waveform between two phases

3.7.2 *Overmodulation I*

The magnitude of each basic space vector is normalized by the maximum value of the phase voltages. Therefore, when the maximum DC link voltage is V_{DC}, the maximum line to line voltage is also V_{DC}. Therefore the maximum phase voltage amplitude (line to neutral) is $\frac{V_{DC}}{\sqrt{3}}$.

In Figure 10:

Above the circle inscribed to the hexagon (green), the voltage waveform of the inverter is distorted. The reason is that it is physically impossible to maintain the vector size in the red zone. Using this yellow area, it **is possible to obtain a greater fundamental (+5%)**, but the harmonics are reinforced too.

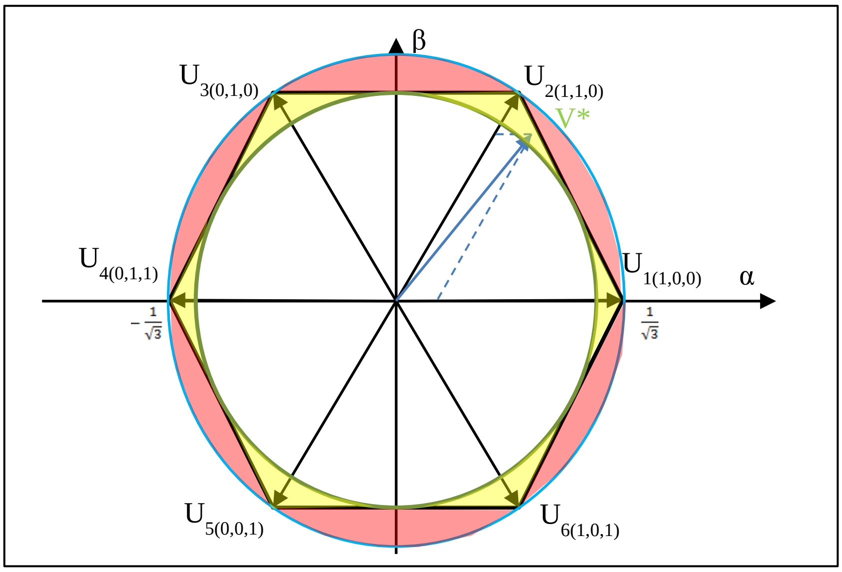


Figure 10 – Overmodulation I 0.907≤M≤0.952

Remark: The coefficient 2/π represents the fundamental amplitude, which is possible to reach with a square wave. This coefficient is taken as reference.

	Maximum amplitude per phase	***Fundamental amplitude***
Linear modulation	$\frac{1}{2} \cdot V_{DC} = 0.5 \cdot V_{DC}$	$0.907 \cdot \frac{2}{\pi} \cdot V_{DC} \approx 0.577 \cdot V_{DC}$
Overmodulation I	$\frac{1}{\sqrt{3}} \cdot V_{DC} \approx 0.667 \cdot V_{DC}$	$0.952 \cdot \frac{2}{\pi} \cdot V_{DC} \approx 0.606 \cdot V_{DC}$

+5%

Figure 11 – Modulation resume

Overmodulation II is not implemented in QUASAR.

3.7.3 Non Linear State Feedback NLSF for IPM/PSM

The feature non linear state feedback NLSF is also called d- and q-axis decoupling compensation. It compensates the cross coupling influence given by the motors voltage equation:

$$\begin{bmatrix} v_q \\ v_d \end{bmatrix} = \begin{bmatrix} R + p \cdot L_q & \omega \cdot L_d \\ -\omega \cdot L_q & R + p \cdot L_d \end{bmatrix} \begin{bmatrix} i_q \\ i_d \end{bmatrix} + \begin{bmatrix} \omega \cdot \lambda_m \\ 0 \end{bmatrix}$$

Due to cross coupling ($U_q = f(I_q, I_d)$, $U_d = f(I_q, I_d)$) the q-axis current control loop and the d-axis current control loop are coupled. That means d-axis current effects q-axis voltage (and vice versa); the NLSF (grey box in Figure 12) does consider these factors:

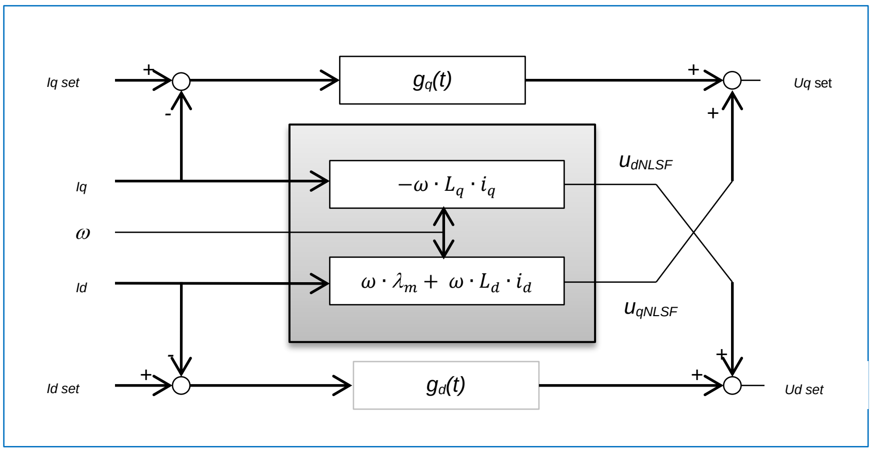


Figure 12 – NLSF Controller

In quasi-stationary situations (low dynamics) the cross coupling can be compensated by the current controllers themselves and NLSF is not necessary. If NLSF is activated the controllers dynamic behavior improves, meaning that steps in the reference value of the torque can be regulated better and faster.

To use NLSF, L_d, L_q and the generator constant need to be known. If NLSF is activated, the stability of the system should be checked again, because the factors of the coupling are dependent on the speed and current. If any of them is oscillating, the output will be affected and will be injected in the input again, which may lead to unstable system behavior.

3.7.4 Field Weakening

3.7.4.1 For IPM/PSM

At higher speed a motor will induce a higher voltage than the q-axis voltage set by the controller. Therefore the torque generating q-axis current cannot flow and the requested torque cannot be delivered. The induced voltage can be limited by adding a d-axis current. This is called field weakening.

Field weakening allows the generation of d-axis current as soon as the U_{dq} absolute vector reaches the value of *Udq absolute vector length 1 (FW) [214B]*. At this point d-axis current will be generated so that the U_{dq} absolute vector is limited to this value.

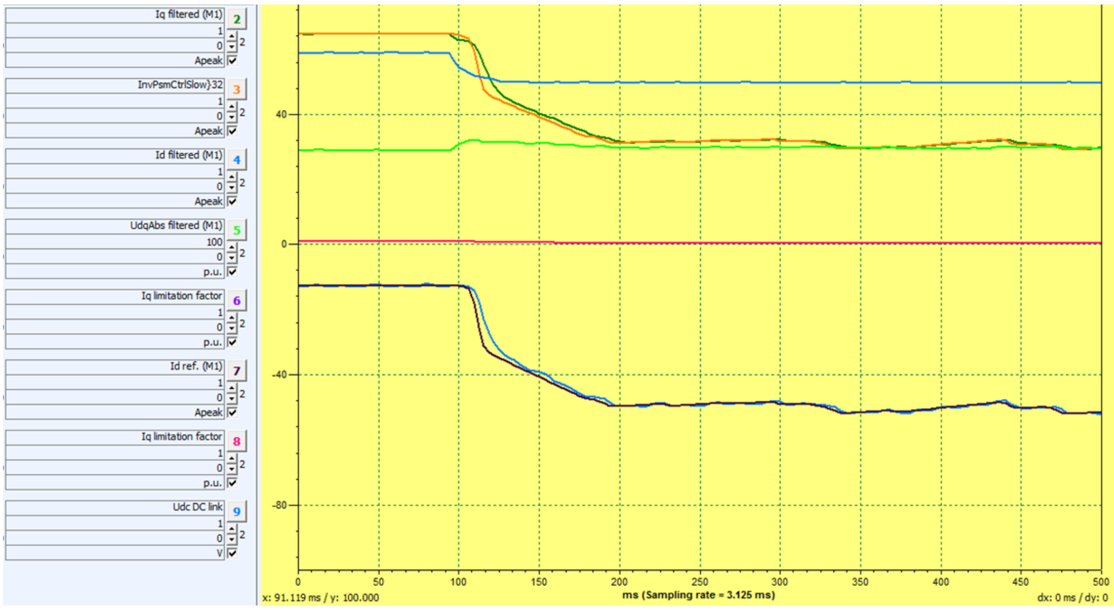


Figure 13 – Field weakening IPM

To configure field weakening behavior see the parameter group *Field weakening* on page 150.

3.7.4.2 For ACIM

For ACIM motors the induced voltage is not caused by the permanent magnets but by the magnetizing current which is the d-axis current generated by the MC. Therefore field weakening is done by reducing d-axis current.

In the field weakening area, the output voltage reaches its maximal amplitude at **0.97p.u**. This value is defined in *Udq absolute vector maximum length [215F]*. Reduction of Id will be done when the filtered Udq voltage exceeds the value of parameter Voltage limit 1 [2495]. Greater reduction is done when Voltage limit 2 [2496] has been exceeded. Above the Voltage limit 3 [2497] also the q-axis current will be reduced.

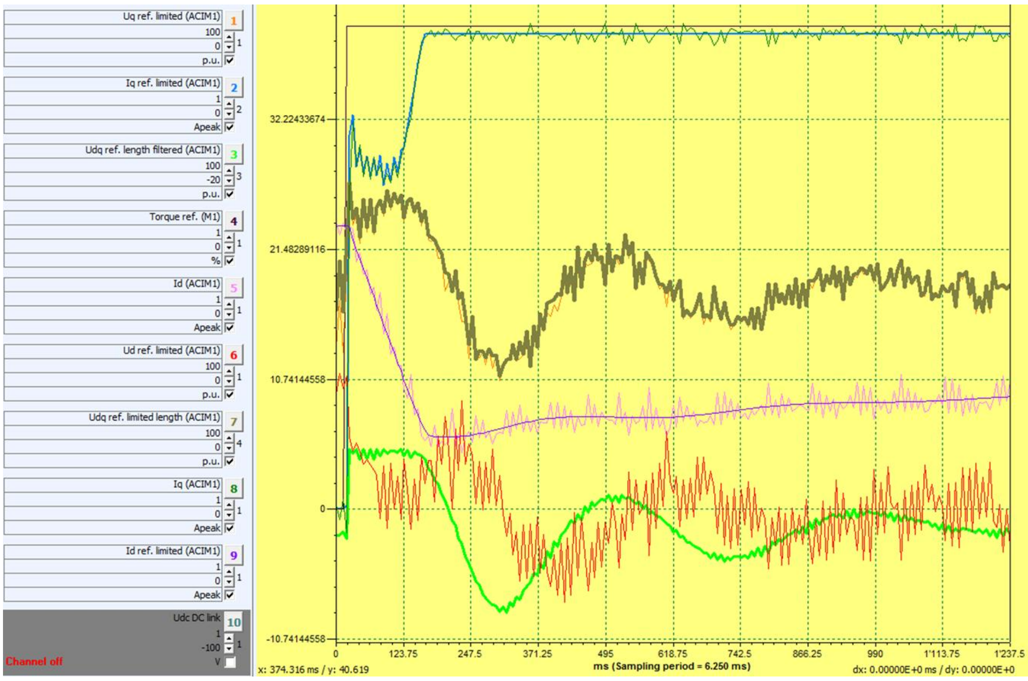


Figure 14 – Field weakening ACIM

3.7.5 Dead Time Compensation

An IGBT needs time to turn on or off. During this time, the current and the voltage do not have ideal step behavior but a linear behavior.

When there are two IGBTs in series, a short circuit could appear if no measures are taken. Therefore dead time is added between turning off one IGBT and turning on the one in series. The result is that on-time is decreased in the signals for the IGBT commands.

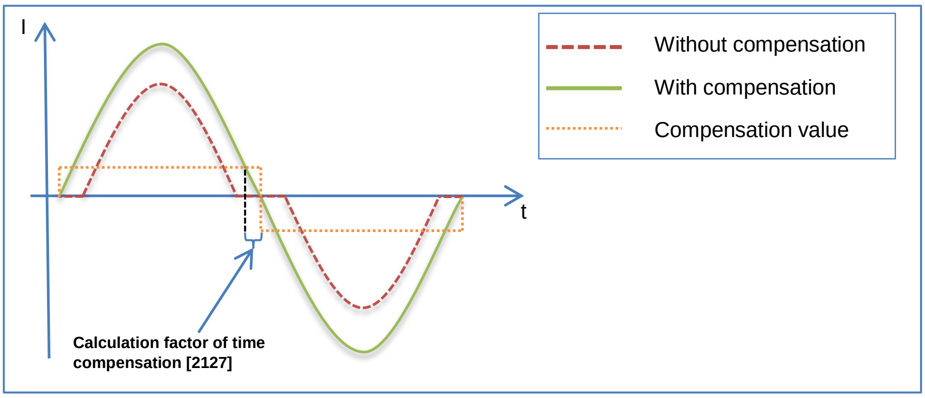


Figure 15 – Current form with and without dead time compensation

QUASAR compensates this effect with the dead time compensation. For small currents, the compensation is deactivated to avoid noise amplification.

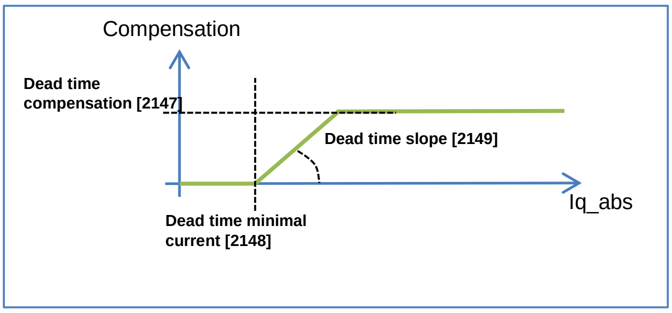


Figure 16 – Dead Time Compensation parameterization

To configure dead time compensation see the parameter group *Dead time compensation* on page 157.

3.8 Peripherals

Most peripherals supported by the different SKAI types are supported by QUASAR. Note that not all digital and analogue inputs and outputs can be mapped to QUASAR functions and therefore some of them are unused.

3.8.1 Position Sensors

For efficient vector control, accurate rotor position information is essential for the motor control to work correctly and with high efficiency.

For PSM and IPMmotors absolute position is required and therefore ABZ Encoders with absolute position (ABZap), Sin/Cos Encoders, Hall Sensors or Resolvers must be used. The main issue there is that after start-up QUASAR needs to be able to determine the correct angle of the motor in order to start motor operation on the desired direction.

For ACIM motors only speed information is required by QUASAR. Therefore an ABZ incremental encoder, even without Z line, provides enough information.

During evaluation phase of the inverter system (SKAI and QUASAR) the definition of the sensor type to be used is very important.

QUASAR supports four different types of position sensors. Not all sensor types are supported by all SKAI types. The following table gives an overview of the available sensor types and the SKAIs supporting them. For details of the electric interface refer also to the SKAI documentation.

Input	***Sensor Type***	***Description***	***Number of Sensors***		
			SKAI HV	SKAI LV single	SKAI LV Dual
PS_DI_xx (one type selectable)	Incremental Encoder ABZ	Sensor provides three digital outputs including two incremental (AB) and one slow (Z) index signal	1x se or 1x di	1	2
	Incremental Encoder ABZap	In addition to normal Incremental Encoder it provides absolute position at start-up	1x se or 1 x di	1	2
	Hall sensors	Hall sensors do not have high enough resolution for vector control but can be used for BLDC mode. Interpolation will be used at high motor speed if used for PSM/IPM.	1	1	2
	Resolver	Provides a two channel analogue signal. An output providing excitation voltage is available in the SKAI[1)]	1[1)]	n/a	n/a
PS_AI_xx or MP_AI_xx	Sin/Cos Encoder	Provides two channel analogue signals that allow absolute position detection at any time.	1 x se or 1 x di	1 x se[2)]	2 x se[2)]
		• di = differential • se = single ended			

Table 8 – Supported Position Sensor Types

[1)] The resolver interface is only implemented in the SKAI HV serial production versions. It is not available in the SKAI HV evaluation and engineering sample versions or in the SKAI LV versions.

[2)] For SKAI LV filters may be implemented depending on the hardware version. Please check SKAI specification to verify if analogue inputs are suitable for Sin/Cos encoder signals.

Please contact local sales for further details.

To configure the position sensors, please refer to the parameter group **Position sensor** on page 115.

The different power supply voltage levels, if supported by the SKAI hardware, can be parameterised (refer to the respective SKAI datasheet).

3.8.2 Motor Temperature Sensors

Motor temperature sensors supported by QUASAR are listed in Table 9.

The range of suitable temperature sensors depends on the SKAI hardware implementation of the temperature measurement circuitry. Because of different implementations not all temperature sensors supported by QUASAR can be used with all SKAI types.

Sensor Type	*Scaling*
KTY16	2000Ω at 25°C
KTY81-1	1000Ω at 25°C
KTY81-2	2000Ω at 25°C
KTY82-1	1000Ω at 25°C
KTY82-2	2000Ω at 25°C
KTY83	1000Ω at 25°C
KTY84	1000Ω at 100°C
KTY85	1000Ω at 25°C
YBB145	1000Ω at 25°C
PT100*	100 Ω at 25°C
PT1000	1000Ω at 0°C
NTC10K *	10kΩ at 25°C
NTC33K *	33kΩ at 0°C

Table 9 – Supported motor temperature sensors

* There are restrictions concerning the usage of these temperature sensors for SKAI LV and SKAI HV evaluation and engineering sample versions.

Please contact local sales for more information.

3.8.3 Error Indication over GPIO

The overlaying system control can indicate errors not only over the CAN bus, but also over a dedicated digital input. The function can be activated and deactivated according to the needs of the system (see parameter *Digital input generates an error [214E]* page 92).

3.9 Warning and Error Functions

QUASAR offers several safety functions on top of the safety functions provided by the SKAI hardware. The safety concept is based on a model with different levels.

1. **QUASAR Warning**
   QUASAR will start progressive torque limiting through the cutback limiters and generate a warning as soon as the minimum or maximum warning level has been reached.
   As soon as the warning zone has been left, the warning is automatically cleared by QUASAR and torque limitation is stopped.

2. **QUASAR Software Trip**
   QUASAR will turn off PWM and generate an error as soon as the minimum or maximum limit has been reached. The overlaying system control can avoid such a situation in normal operation by correctly reacting upon reaching a QUASAR warning level.
   If a trip condition occurs PWM will be disabled within 1ms and the error will be indicated over the CAN bus 500us later.

3. **Hardware Trips**
   Hardware trips are detected by the LCU in the SKAI and should never occur if QUASAR is configured correctly.

After an error has been generated, the error must be cleared before PWM can be enabled again. Errors are not stored persistently by QUASAR; therefore active errors and the error details are lost after restarting of the SKAI system.

Figure 17 below shows an overview of the warnings and errors reported by QUASAR. Further it visualizes the minimum and maximum cutback filters with the warning and error levels. Warnings and errors will not be reported for all cutback limiters, please refer to Table 12 and Table 13 for details.

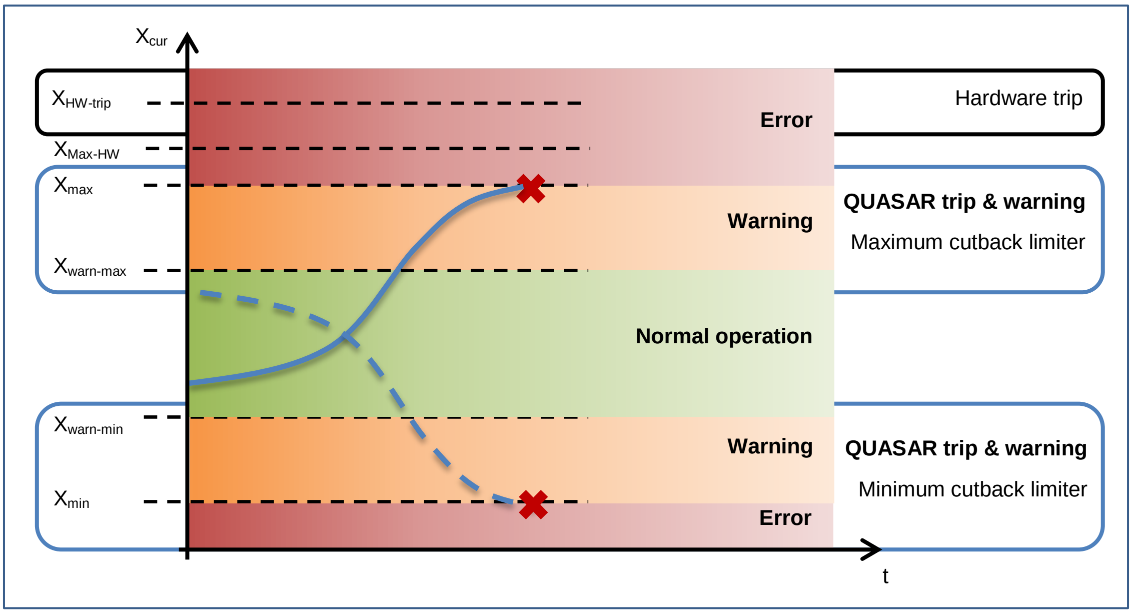


Figure 17 – Safety Levels

The QUASAR error limits should be set based on the respective datasheet values of the SKAI inverter.

The main task of the cutback limiters is to detect critical situations and to apply immediate cutbacks in order to enable the overlaying control (e.g. the ECU/VCU) to react in a timely manner on the warning indicated by QUASAR.

Depending on the actual operation state of a system, a safe reaction on warning may be achieved in different ways. Possible actions may be to turn off PWM or to reduce torque. It is up to the overlaying control to decide what action is taken.

3.9.1 Hardware Trips

QUASAR handles all hardware trips detected by the SKAI. As soon as one of the following errors is indicated by hardware (maximum value $X_{HW\text{-}tirp}$ has been reached) the PWM is turned off and a respective error is indicated over CAN.

In a correctly configured system HW trips should never occur.

Table 7 lists the HW trips propagated over CANopen.

Error	*Description*	*Power module error value*
Desaturation (V_{CE} detection)	Overcurrent or short-circuit condition detected.	0x01
5V supply low	Secondary side undervoltage detected	0x02
Overtemperature (DCB or PCB)	DCB temperature or PCB temperature above threshold detected	0x04
Auxiliary supply low	The voltage of auxiliary power supply dropped below the safe value.	0x08
Overcurrent	Positive or negative overcurrent detected	0x10
n/a	Reserved	0x20
n/a	Reserved	0x40
DC link overvoltage	DC-link voltage above threshold detected	0x80

Table 10 – Hardware trips

3.9.2 Simple Limiters

Simple limiters only define the maximum value and will directly generate an error when reached. The respective value will be limited to the maximum value. For these limiters no warning is generated.

The following simple limiters are defined:

Limiter input	*Parameter Max*
Maximum current difference	*Maximum current difference [2146]*
Maximum Power	*Maximum power [2145]*

Table 11 – Simple limiters

3.9.3 Cutback Limiters

QUASAR implements several cutback limiters to make sure that the overlaying system control can react on critical situations. Minimum and maximum limiters are available.

Some limiters generate a warning as soon as limiting starts and an error is generated when the maximum value has been reached and the PWM is disabled.

In addition to the warning sent over PDO, two SDO objects 0x20a8 and 0x20a7 can be requested to get information about the active limiters and the actual limitation factor (refer also to [1]).

3.9.3.1 Maximum Cutback Limiters

The maximum limiter is used to generate a warning as soon as the current value (X_{act}) rises above the warning level ($X_{warn\text{-}max}$). Further torque is limited progressively by a linear limiting factor.

If X_{min} is reached, QUASAR will generate a software trip.

SKAItek, Keltenstrasse 1, CH-2563 Ipsach, Phone +41 32 332 79 32, Fax +41 32 332 79 31

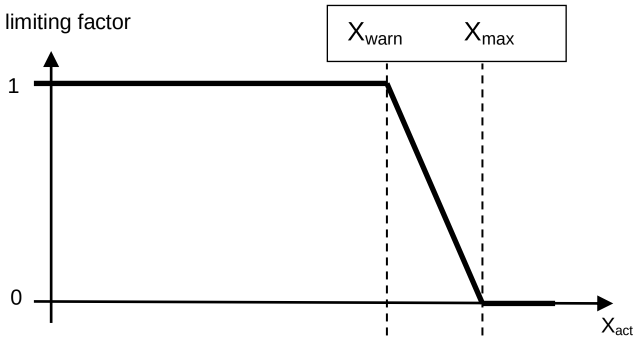


Figure 18 – Maximum Cutback Limiter

Maximum limiters are implemented for the following values supervised by the SKAI:

Limiter input	*Parameter Warning / Start*	*Parameter Max*	*Warning*	*Error*
Motor temperature	*Warning motor temperature [2109]*	*Maximum motor temperature [210A]*	System warning 0x04	System Error 1 0x04
PCB temperature	*Warning PCB temperature [2107]*	*Maximum PCB temperature [2108]*	System warning 0x01	System Error 1 0x01
DCB temperature	*Warning DCB temperature [210B]*	*Maximum DCB temperature [210C]*	System warning 0x01	System Error 1 0x01
DC link voltage	*Warning maximum DC link generator voltage [2118]*	*Maximum DC link voltage [2106]*	System warning 0x10	System Error 1 0x02
Acceleration of motor	*Acceleration limit start [216C]*	*Maximum acceleration [216D]*	System warning 0x10	No error generated, PWM not disabled
Over speed	*Warning speed [2104]*	*Maximum speed [2102]*	System warning 0x10	System Error 1 0x20

Table 12 – Maximum Cutback Limiters

3.9.4 Minimum Cutback Limiters

The minimum limiter is used to generate a warning as soon as the actual value (X_{act}) drops below the critical value (X_{warn}). Further torque is limited progressively by a linear limiting factor.

If X_{min} is reached, QUASAR will generate a software trip.

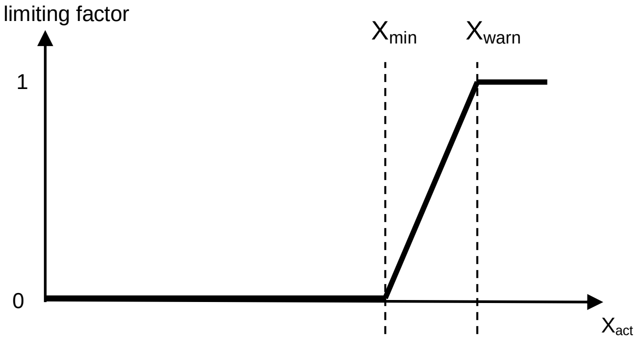


Figure 19 – Minimum Cutback Limiter

Only one minimum cutback limiter is available.

Value	Parameter Critical Minimum	Parameter Minimum	Warning Critical	Error
DC link voltage	Warning minimal DC link voltage [2117]	Minimal DC link voltage [2105]	System warning 0x10	System Error 1 0x00000020

Table 13 – Minimum Cutback Limiters

3.9.5 Encoder Error Detection

For ABZ and ABZap encoders error detection is implemented. The error is generated when the signals on AB lines do not match with the index received on the Z line.

Figure 20 shows an example for a situation, when an error is generated. In this situation the configured number of lines is greater than the effective lines detected before receiving an index signal. For this reason the error counter is incremented whenever an index is received. If the *Encoder lines drift error limit [2115]* is reached an error counter is incremented. If the error counter reaches the limit of *Encoder lines drift error count [2116]* an encoder error is reported (System error 2: 0x40)

The error counter will be cleared if the detected lines reach a value within the Lines-Drift-Ignore-Limit.

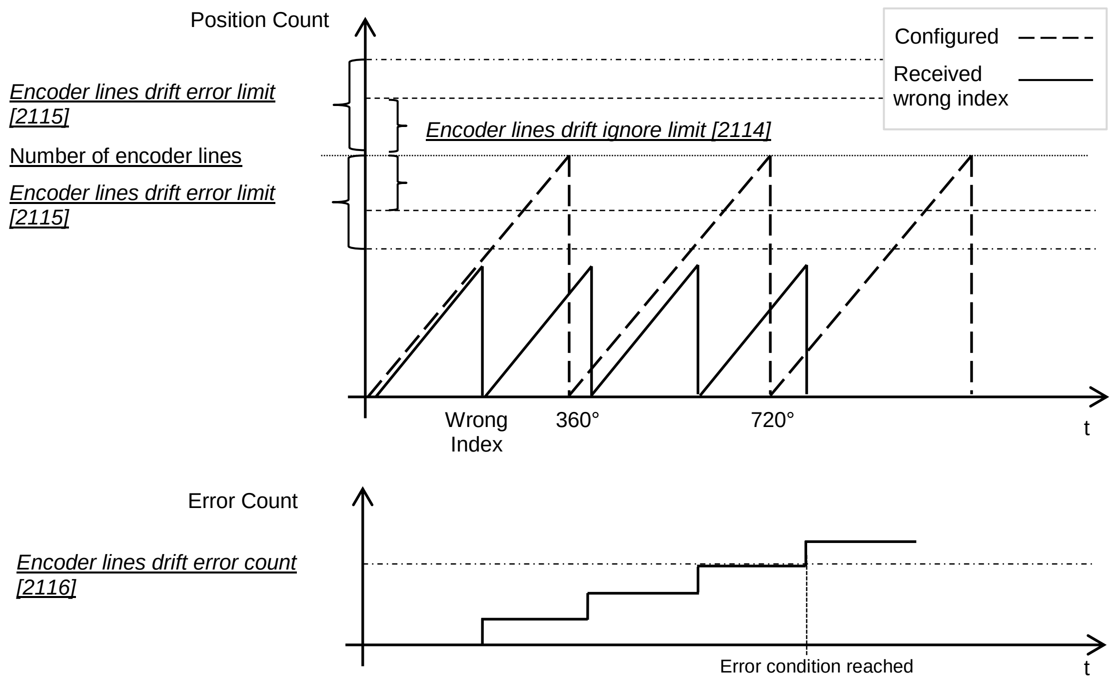


Figure 20 – Encoder Error Detection

3.9.6 DC Link Overvoltage Protection

This feature is only implemented for the SKAI LV single and dual.

The feature is used to protect the inverter against high voltages induced by PSM or IPM machine at high speed. Depending on the motor characteristics (i.e. if it is designed to deal with short-circuited windings) switching on all BOT switches can help in such a situation to keep the DC link voltage within safe levels

The overvoltage protection is used to protect the hardware against overvoltage. If the DC Link voltage is greater than the specified value in parameter Overvoltage protection ON max DC link voltage [217C] all the BOT switches will be turned on and therefore protect the inverter from excessive overvoltage. The BOT switches are afterwards turned off again, as soon as the DC Link voltage is lower than Overvoltage protection OFF minimal DC link voltage [217B].

Depending on the LCU version of the SKAI LV, this feature may not be available. For further information contact local sales.

3.10 Communication

The configuration and operation of QUASAR is controlled over CAN bus communication running the CANopen protocol. The profile used in QUASAR has been derived from DS301. More information about the interface to QUASAR can be found in CAN protocol definition [1].

For SKAI LV dual system QUASAR implements a separate node I_d for each motor. Depending on which node I_d is addressed the corresponding motor is addressed. This applies for the whole CANopen interface.

Table 14 shows the default node IDs of QUASAR. They can be configured.

Entity	*Default node I_d*	*Parameter*
Motor 1	0x7A	*Node ID [20F3]*
Motor 1 Scope	0x7C	*Scope node ID [20F4]*
Motor 2 (SKAI LV dual system only)	0x7B	*Node ID [20F3]* (in parameter set for node 2)
Motor 2 Scope (SKAI LV dual system only)	0x7C	*Scope node ID [20F4]* (in parameter set for node 2)

Table 14 – CANopen default node IDs

Some SKAI types feature two CAN interfaces. QUASAR only supports one CAN interface (CAN_A).

3.11 Parameters

QUASAR implements a set of parameters to configure the system. They are grouped in different categories.

Depending on the parameter, the value is applied immediately or a reset is required for the new value to be applied. Information about this behavior is given in the parameter description.

The full parameter list can be found in Appendix B – Parameter Description.

While tuning a system it is very handy to work with parameters that apply directly without restart.

Nevertheless it is advised for safety reasons to always store parameters to EEPROM and restart the SKAI to apply them.

3.11.1 Parameter Groups Overview

The parameters for the QUASAR software are organized in different groups. Each group holds a number of parameters, which are described in the following group description.

Parameters

+ Inverter
+ DC link
+ Motor
+ Position sensor
+ Vector control
+ Current control
+ Field weakening
+ Dead time
+ Speed control
+ Dual-System
+ CANopen
+ Tables

Manufacturers use different conventions in their motor specifications.

QUASAR uses the following values:

- Resistance and inductance values of a single phase winding
- Peak values for voltages and currents unless specified otherwise

3.11.2 Range Checks and Validations

QUASAR does not implement any range check for the parameter interface. It is up to the user to make sure that values are consistent and in an appropriate range.

For most parameters no validation will be carried out. There are some parameters where a validation task corrects values if they are not correct. Such values will be overwritten immediately by QUASAR but the changes can only be seen if the parameter value is read back manually.

3.11.3 Parameter Types

The parameters are stored as variables; therefore they are of a specific type. The table below gives an overview of the different types.

Type	*Bits/Bytes*	*Description*	*Range*
DT_I8	8 Bits / 1 Byte	signed char	-128 … 127 / $-(2^7)$ … $(2^7) - 1$
DT_I16	16 Bits / 2 Bytes	signed short	-32768 … 32767 / $-(2^{15})$ … $(2^{15}) - 1$
DT_I32	32 Bits / 4 Bytes	signed long	-2147483648 … 2147483647 $-(2^{31})$ … $(2^{31}) - 1$
DT_I64	64 Bits / 8 Bytes	signed long long	$-(2^{63})$ … $(2^{63}) - 1$
DT_U8	8 Bits / 1 Byte	unsigned char	0 … 255 / 0 … $(2^8) - 1$
DT_U16	16 Bits / 2 Bytes	unsigned short	0 … 65535 / 0 … $(2^{16}) - 1$
DT_U32	32 Bits / 4 Bytes	unsigned long	0 … 4294967295 / 0 … $(2^{32}) - 1$
DT_U64	64 Bits / 8 Bytes	unsigned long long	0 … $(2^{64}) - 1$
DT_BOOL	8 Bits / 1 Byte	signed char	-128 … 127 / $-(2^7)$ … $(2^7) – 1$ DT_FALSE = ((DT_BOOL)0) DT_TRUE = ((DT_BOOL)1)
DT_F32	32 Bits / 4 Bytes	float	Rational number

Table 15 – Variable types

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3.11.4 Flag Parameter Notation

Warning and error values as well as some configuration settings are defined as flag parameters. Each bit of the parameter is used to indicate if an error is active or inactive or if an option is enabled or disabled respectively.

Example:

Error / Option	*Hexadecimal value*	*Flag (binary value)*
Feature 1	0x0000 0001	0000 0000 0000 0000 0000 0000 0000 0001
Feature 2	0x0000 0002	0000 0000 0000 0000 0000 0000 0000 0010
…	…	…
Feature 32	0x0080 0000	0000 0000 1000 0000 0000 0000 0000 0000

Table 16 – Flag parameter notation

To enable feature 1 and feature 2 calculate the sum of the hex values. The result will be 0x0000 0003.

The respective hexadecimal values can be summed using a calculator with hexadecimal support.

3.11.5 IPM Machine Characteristics

In order to tune IPM machines for best efficiency, tables are used to characterize them. QUASAR implements several tables that can be configured over CANopen interface.

Table 17 defines the dimension and units for each available table. The dimensions given include one row and one column respectively which define the used scales.

Characteristic		*Columns (x-axis)*			*Rows (y-axis)*		
Value	Unit	Value	Unit	Size	Value	Unit	Size
d-axis current	A_{peak}	Speed (n) (1)	rpm	27	Torque (T) (2)	p.u.	52
q-axis current	A_{peak}	Speed (n) (1)	rpm	27	Torque (T) (2)	p.u.	52
d-axis inductance	mH	Iq_{abs} (1)	A_{peak}	26	Id_{abs} (1)	A_{peak}	26
q-axis inductance	mH	Iq_{abs} (1)	A_{peak}	26	Id_{abs} (1)	A_{peak}	26
Maximum torque	Nm	Speed (n) (1)	rpm	27	Generator/Motor (3)	-1 / 1	3
Absolute current	A_{peak}	Speed (n) (1)	rpm	27	Generator/Motor (3)	-1 / 1	3

Table 17 – IPM motor characterization tables

Further the table must comply with the following rules:

(1) Scales must start at zero and increase arithmetically (linear)

(2) Negative torque means generator mode. Row 26 must contain Torque 0. Row 1 contains highest generator torque (smallest negative value) and must increase arithmetically.

(3) -1 defines value in generator mode. 1 defines value in motor mode. Generator mode must be listed first.

IPM motor characteristics must be either given by the motor manufacturer in a datasheet or must be measured on a test bench. In case they are available, the scales may need to be adapted to fit the rules defined above.

An example file for IPM table characteristics is provided with Q-Control.

3.12 Q-Control

Q-Control is the PC based tool to configure and operate the QUASAR software on a SKAI system. By using Q-Control, setting up of a system is straight forward because it implements the full QUASAR CANopen interface and provides a GUI to configure the system.

Q-Control provides the following main functions:

- ECU Simulation: QUASAR can be controlled by Q-Control (Torque, Speed, On/Off command) during setup or for test purposes
- Display of actual operation values
- Visualization and recording of variables in the Scope
- Configuration of parameters with import and export functions
- CAN Logger: Supervising and logging of CAN communication
- QUASAR software update
- Control test mode supported by QUASAR

For more information see the Q-Control documentation [2].

Q-Control is not included when purchasing a QUASAR software license. Q-Control is a very useful tool for tuning and testing and has to be purchased separately. Please contact local sales for more information.

Q-Control is running under Windows XP and Windows 7 (32 and 64 bit versions).

4 Setup Guide

This chapter explains the steps to be performed to set up your system. QUASAR supports a wide range of motor types and peripherals; therefore the configuration involves several steps.

The following figure shows an overview of the steps to be completed. Each step will consist of several actions to be performed. It will be used to visualize which step is handled in each chapter.

Figure 21 – Setup process

The steps defined in the setup process should be carried out in the proposed order.

Step	***Tasks***
Cabling	• Wire up and connect the used devices such as motor, DC supply and sensors
Q-Control	• Install Q-Control on your computer • Establish communication with QUASAR
Basic Settings	• Set basic parameters to allow further steps • Information about units used in QUASAR
Position Sensor	• Position sensor settings • Calibrate sensor offset and phase lag
Limiter Settings (common)	• Configure remaining limiters and safety parameters
Motor Control Settings	• Define the motor type • Basic motor settings • Advanced MC settings

Table 18 – Setup steps for QUASAR

4.1 Step instructions

The following chapters will define all setup step with several sub-steps. Each sub-step is structured in the same way.

Setup and Preconditions

Provides information about the hardware setup, the operating point and the parameters needed in order the setup step can be performed.

Criteria

Gives information about the criteria the must be verified for successful tuning

Parameter

Lists all parameters involved in the setup step. Further information is given how a specific parameter is to be used.

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Scope Settings

For some tests steps a predefined Q-Control scope setting file (*.ssf). It defines a workspace that can be loaded in the Q-Control scope to load the scope channels required for the test to be done.

For information about the values measured in each channel, the address description given in Q-Control can be read (select the channel, click on the button on the right of the “Address” field.

For further details refer to the Q-Control user manual [2].

Procedure

The procedure defines the actual step by step tutorial to do the setup.

For tests steps involving measurements with the Q-Control scope, captures of expected results are available.

For some procedures calculations need to be done. Templates for these calculations are provided by the setup calculations excel sheet [3].

5 Setup Guide – Cabling

QUASAR supports three SKAI inverter types, four different position sensors and four different types of motors. Therefore the number of possible combinations is rather big and no default wiring exists. Refer to the respective SKAI specification for more information on the electrical and mechanical interface.

When defining the system, the electrical compatibility of all peripherals must be verified to avoid problems during the configuration of QUASAR

5.1 Signal Naming Convention

QUASAR motor control software supports different SKAI inverter types. SKAI HV and SKAI LV use different naming of peripherals in the respective datasheet. QUASAR has to use all signals provided and therefore this manual needs to reference them. A convention for the mapping of the signals has been defined to address this problem.

Generally the QUASAR software and user manual use the pin notation as defined for SKAI2 HV.

The figure below shows the two mapping layers used in this manual to address the variety of possible combinations.

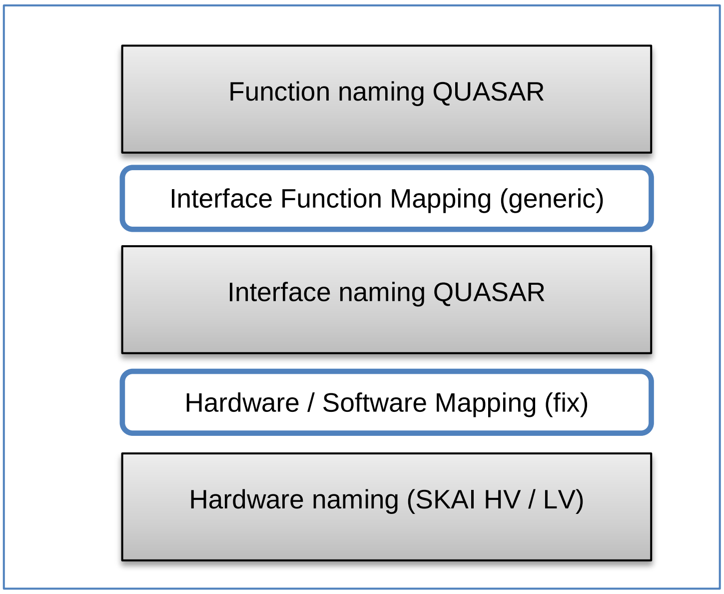

Figure 3 – Naming concept QUASAR

5.2 Hardware/Software Mapping

The naming for interfaces in QUASAR is based on the naming used for SKAI HV. The following mapping table shows the respective interface names for SKAI LV.

QUASAR Peripheral	*SKAI HV*	*SKAI LV single*	*SKAI LV Dual*	*Description*
ELX	ELX	CAN-BMS	CAN-BMS	Signal power on/off (ignition)
n/a	PS_PWR	ENC_PWR*	ENC-1-PWR	Digital position sensor power
PS_DI_A	PS_DI_AP	ENC_PHA[1)]	ENC-1-PHA[1)]	Digital position sensor track A / Resolver excitation (pos, HV only)
PS_DI_B	PS_DI_BP	ENC_PHB[1)]	ENC-1-PHB[1)]	Digital position sensor track B / Resolver sinus track (pos, HV only)
PS_DI_C	PS_DI_NP	n/a	n/a	Digital position sensor track Z (index) B / Resolver cosine track (pos, HV only)
n/a	n/a	n/a	ENC-2-PWR[1)]	Digital position sensor power of encoder 2
PS_DI_A_2	n/a	n/a	ENC-2-PHA[1)]	Digital position sensor track A
PS_DI_B_2	n/a	n/a	ENC-2-PHB[1)]	Digital position sensor track B
MP_AI_C1	MP_AI_C1P	GPAI1_ANA[3)]	GPAI1_ANA[3)]	Differential multipurpose analog input 1 (pos.)
PS_AI_C1	PS_AI_C1	n/a	n/a	Analogue Sin/Cos position sensor 1 (single ended)
PS_AI_C2	PS_AI_C2	n/a	n/a	Analogue Sin/Cos position sensor 2 (single ended)
CANA	CANA_H	CAN_H	CAN_H	CAN channel A high line
CANA	CANA_L	CAN_L	CAN_L	CAN channel A low line
CANB	CANB_H	n/a	n/a	CAN channel B high line
CANB	CANB_L	n/a	n/a	CAN channel B low line
MP_DO_C1	MP_DO_C1	GPxo1_NEG	GPxO1_NEG	Multipurpose digital output 1
PS_DI_A	PS_DI_AN	ENC_nPHA	ENC-1-PHA[1)]	Digital position sensor track A / Resolver excitation (neg, HV only)
PS_DI_B	PS_DI_BN	ENC_nPHB	ENC-1-PHB[1)]	Digital position sensor track / Resolver sinus track (neg, HV only)
PS_DI_C	PS_DI_NN	ENC_INDEX[1)]	n/a	Digital position sensor track Z (index) / Resolver cosine track (neg, HV only)
MP_AI_C1	MP_AI_C1N	GPAI1_RET[3)]	GPAI1_RET[3)]	Differential multipurpose analog input 1 (neg.)
TS_AI_MOT	TS_AI_MOT	MTEMP_POS[2)]	MTEMP-1-POS[2)]	Motor temperature analogue input
n/a	n/a	MTEMP_NEG[2)]	MTEMP-1-NEG[2)]	Motor temperature analogue input (neg.)

QUASAR Peripheral	***SKAI HV***	***SKAI LV single***	***SKAI LV Dual***	***Description***
TS_AI_MOT_2	n/a	n/a	MTEMP-2-POS[2)]	Motor 2 temperature analogue input
n/a	n/a	n/a	MTEMP-2-NEG[2)]	Motor 2 temperature analogue input (neg.)
MP_AI_C2	MP_AI_C2P	GPAI2_ANA[3)]	GPAI2_ANA[3)]	Differential multipurpose analogue input 2 (pos.)
MP_AI_C2	MP_AI_C2N	GPAI2_RET[3)]	GPAI2_RET[3)]	Differential multipurpose analogue input 2 (neg.)
MP_DI_C1	MP_DI_C1	GPDI1	GPDI2	Multipurpose digital input 1
MP_DI_C2	MP_DI_C2	GPDI2	GPDI2	Multipurpose digital input 2
MP_DO_C2	MP_DO_C2	GPxo2_NEG*	GPxO2_NEG	Multipurpose digital output 2

Table 5 – Hardware/Software Mapping

1) Depending on SKAI LV type hardware limitations may apply

2) Depending on SKAI LV type sensor types may not be supported (scaling)

3) For some SKAI LV types use of Sin/Cos encoders may not be supported due to hardware filters. Please contact local sales if such interfaces are required.

Not listed interfaces provided by the SKAI hardware are not supported by QUASAR

5.3 Function Mapping

Some functions can be mapped to different peripherals (e.g. digital input). This mapping involves an additional abstraction level

SKAI Interface	QUASAR Function	Generic Mapping Parameter
MP_DI_C1	Error input INX	*Digital input generates an error [214E]*
TS_AI_MOT	Motor Temperature	Fixed, no mapping
MP_AI_C1/MP_AI_C2	Differential analog input for Sin/Cos position sensor	*Enable with Configuration hardware [2140]*
PS_AI_C1/ PS_AI_C2	Single ended analog input for Sin/Cos position sensor	*Enable with Configuration hardware [2140]*
MP_DO_C1 or MP_DO_C2	Angle output	*Configuration hardware [2140]*
MP_DO_C1 or MP_DO_C2	CANopen controlled output	*Configuration hardware [2140]*
MP_DO_C1 or MP_DO_C2	Error output	*Configuration hardware [2140]*

Table 5 – Hardware/Software Mapping

5.4 Cabling Examples

This chapter gives two examples of systems including SKAI inverters.

For further information refer to the SKAI hardware documentation.

5.4.1 SKAI HV

The basic setup of a system with a SKAI HV is quite similar to one with a SKAI LV single inverter.

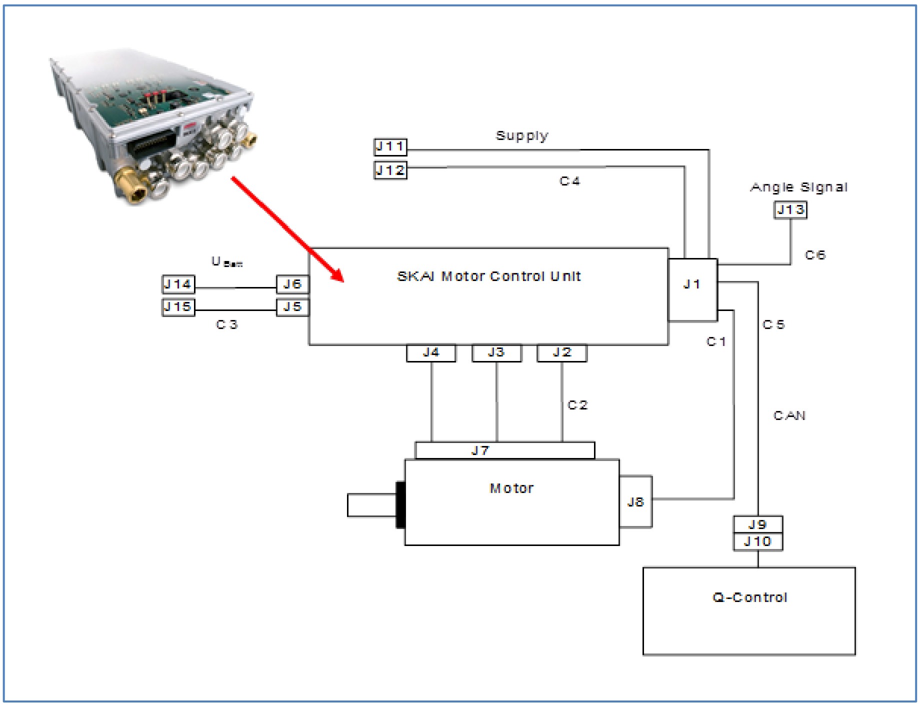

Figure 22 – SKAI HV System Setup

5.5 SKAI LV DUAL

The dual system allows controlling of two motors. QUASAR implements this over two separately controllable CANopen nodes.

During definition of a dual system, limited availability of position sensor interfaces must be considered.

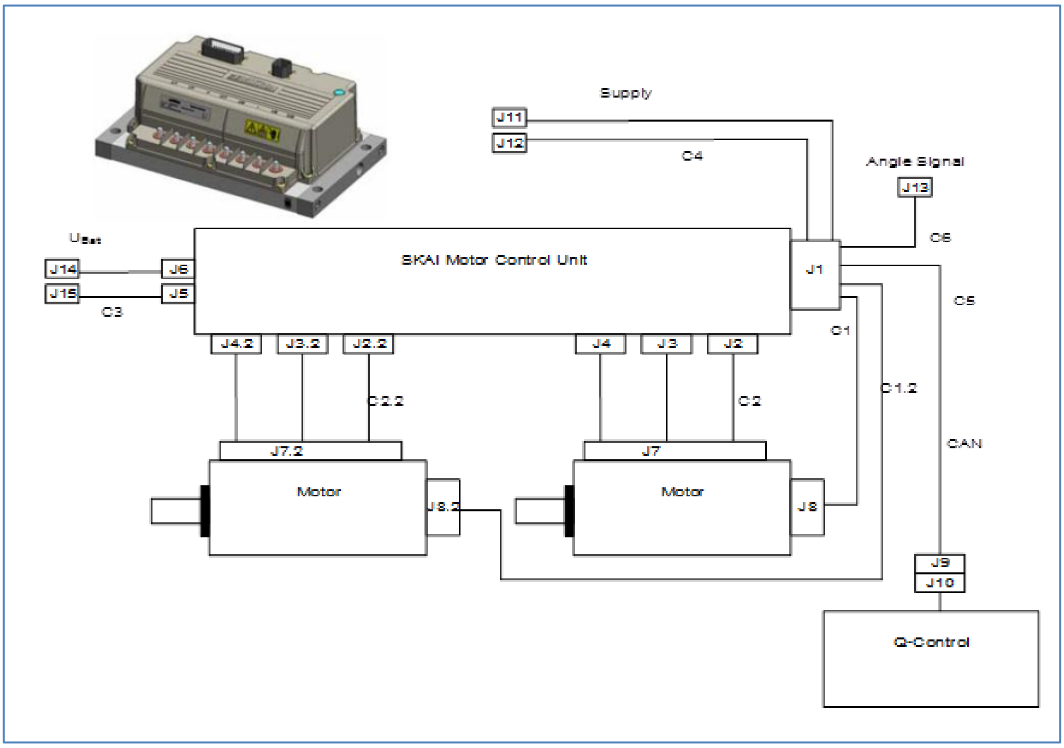

Figure 23 – SKAI LV DUAL wiring

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6 Setup guide – Communication Check

After the cabling of the SKAI is completed, it is recommended to check the communication with the inverter system. For this task the desktop application Q-Control can be used.

6.1 Installation

The installation of Q-Control is simple. It includes the installation of the PCAN-USB adapter and the software installation on your PC (for more information refer to the Q-Control User Manual [2]).

6.1.1 CAN Adapter

Q-Control supports communication over CAN using the PCAN-USB adapter from Peak Systems. The licensing of Q-Control is based on this type of CAN adapter. A specific PCAN-USB adapter has to be purchased from SEMIKRON or drivetek sales. Each CAN adapter includes one runtime license for Q-Control.

PCAN-USB adapters not purchased through SEMIKRON or drivetek sales will not work with Q-Control, because they do not contain the Q-Control license.

The driver for the CAN interface must be installed before starting Q-Control. Install the driver either from the CD delivered with the PCAN-USB adapter or download it from the web page of Peak Systems.

QUASAR only support one CAN interface of SKAI hardware. Connect the PCAN adapter to the CAN_A interface of the SKAI. A termination resistor of 120 Ohm must be used to allow communication. Either an external resistor can be used or an internal resistor in the SKAI can be if available (refer to the SKAI hardware documentation for details).

6.1.2 Q-Control

Double click the installation wizard (download from www.quasar.skaitek.ch) and follow the instructions.

By default the application will be installed in the program file folder (Program Files\SKAItek\Q-Control) and will create some registry keys.

6.2 Programming QUASAR Firmware

If you have purchased a SKAI with QUASAR software, only the QUASAR Bootloader is installed on the device. You will have to install QUASAR firmware before being able to use the SKAI.

If the QUASAR Bootloader is installed on the SKAI, the flash of the DSP is locked. Therefore it is not possible to install any other firmware than QUASAR.

6.3 Downloading QUASAR Firmware

1. Connect the PCAN adapter to the PC and the SKAI
2. Start Q-Control
3. Configure the CAN interface: View → Communication Settings
    a. Select 250kBit/s
    b. Node I_d MC 1 must be 0x10 (default setting)

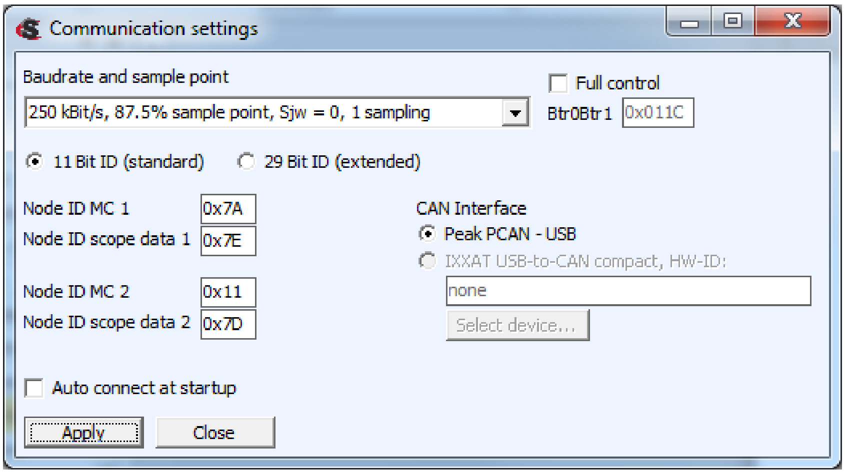

Figure 24 – Q-Control Communication Settings

4. Open Flash tool: View → Flash (see Figure 25)

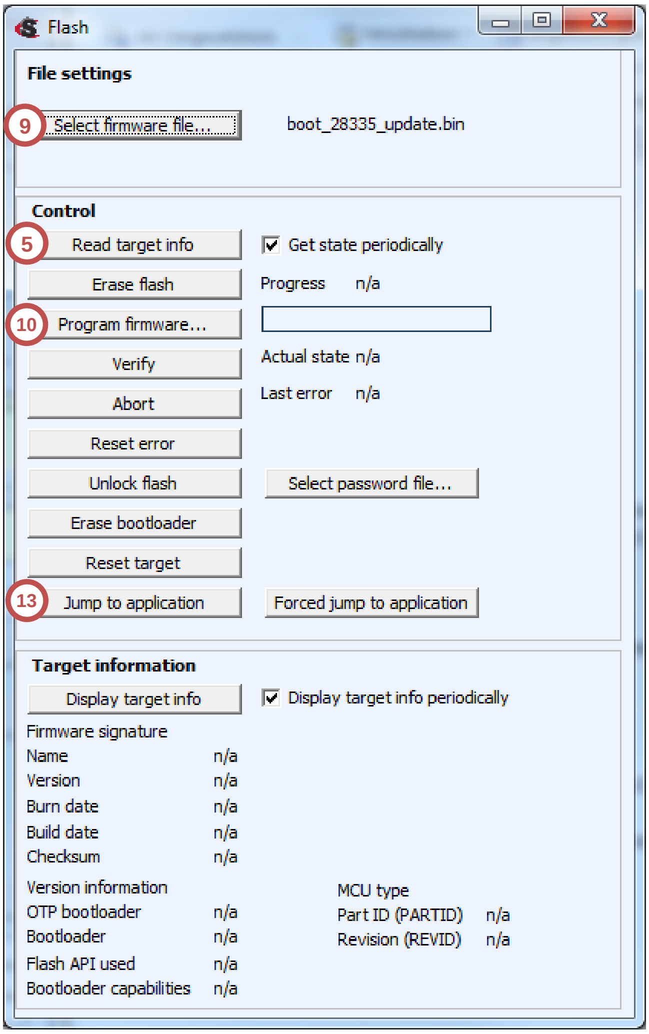

Figure 25 – Q-Control Flash view verify

Depending on the version and configuration of Q-Control on the PC, you might see additional buttons.

Once a firmware file has been selected, Q-Control will remember that file even after restart.

5. Check connection: Click button “Read target info” (see Figure 25)

6. Turn on auxiliary power supply of the SKAI
7. Confirm the popup window by pressing the “OK” button

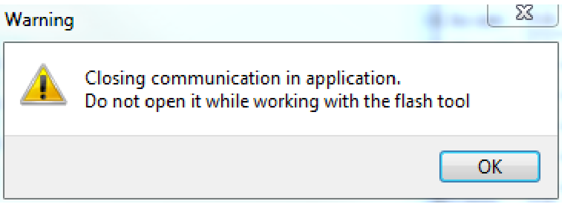

Figure 26 – Quit QUASAR and jump to Bootloader

8. If no information similar to Figure 27 is shown, press the “Reset error” button and repeat from step 5. If this does not help check your setup, press the “Reset error” button and repeat from step 1.

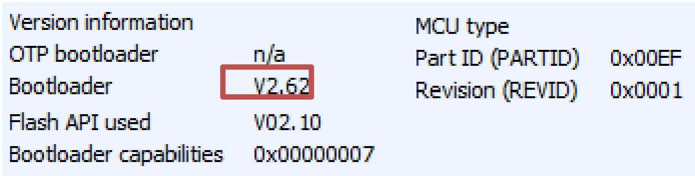

Figure 27 – Target Info

Depending on the SKAI type and version you are using a different Bootloader version will be indicated.

9. Press the button “Select firmware file…” and choose the binary file of the firmware.

10. Click on “Program firmware…” button and confirm in the pop-up window by clicking the “Yes” button.
11. Click on the “Program firmware” button in the second pop-up window

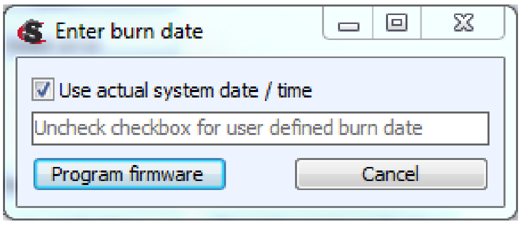

Figure 28 – Q-Control flash date/time window

12. Wait for the programming to complete

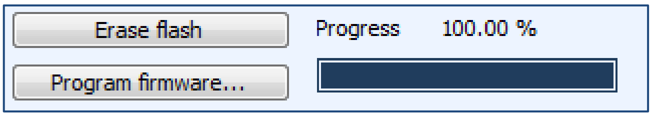

Figure 29 – Programming and Erasing progress

13. Press the button “Jump to application” to start the uploaded firmware.

QUASAR is now running. After restarting the SKAI, QUASAR will automatically start from now on.

6.4 Main Window

Navigate to the Start Menu → Q-Control and start Q-Control. The Main Window appears.

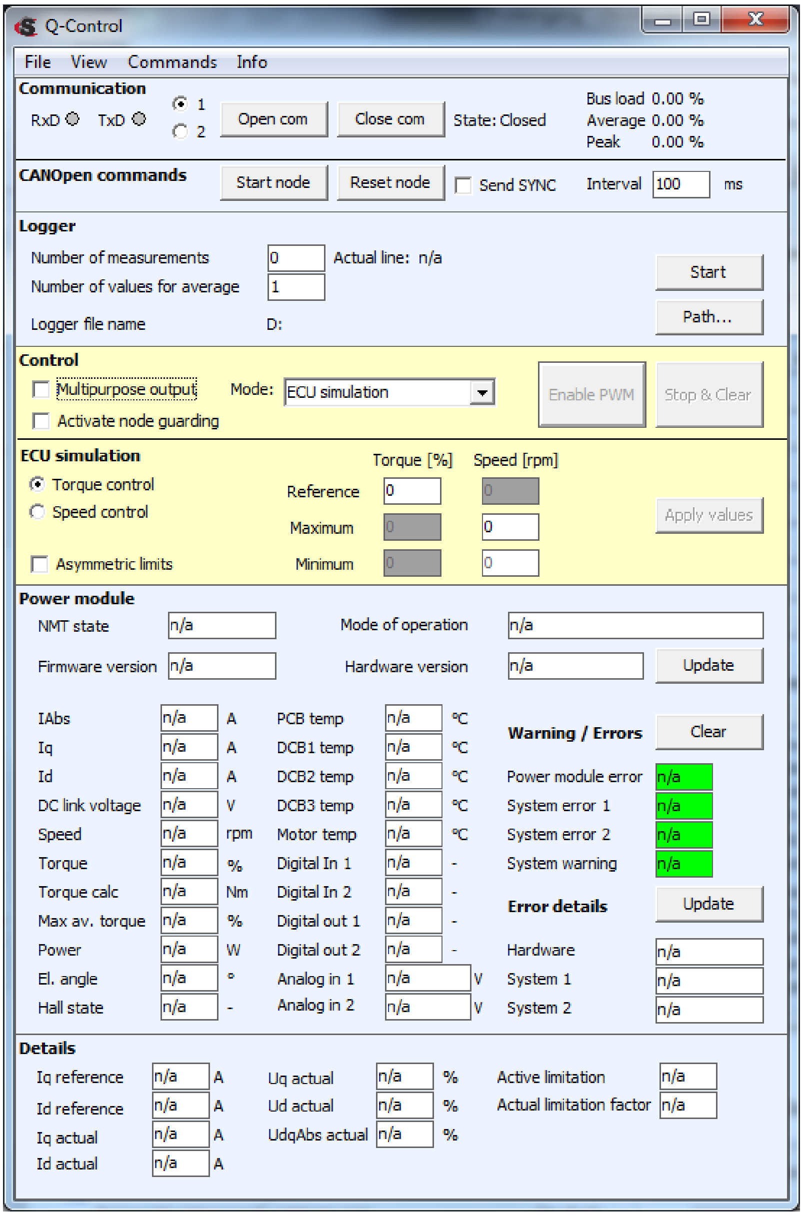

Figure 30 - Q- Control Main Window

6.4.1 Start Communication

After a reset or new start-up the SKAI will send a boot-up message and remain in pre-operational state. Therefore it will not communicate with Q-Control. To establish normal communication, the following steps have to be performed. These steps have to be repeated after each reset.

The commands can be sent either form CAN Logger window or from the Main window.

1. Activate “***Activate node guarding***”
2. Activate “***Send SYNC, interval 100 ms***”
   - The actual values in the main window will only be refreshed automatically if Send SYNC is activated.
3. Press the “***Start Node***” button
   - After receiving the Start Node command, QUASAR starts communicating over CAN

Command	*Action*
Enter pre-operational	CAN goes to pre-operational state. It is only possible to configure QUASAR. Reference values over PDO are ignored. Only needed after Stop Node has been sent.
Start Node	CAN is fully operational
Reset Node	Resets the CPU

Table 19 – CAN NMT commands

6.4.2 Verify Ccommunication

If the SKAI is already programmed with a firmware the TxD and RxD on the ***Main Window*** should be blinking.

- RxD blinks green when messages are received.
- TxD blinks when Q-Control sends messages (normally some SDO are sent to get a part of the actual values and settings).

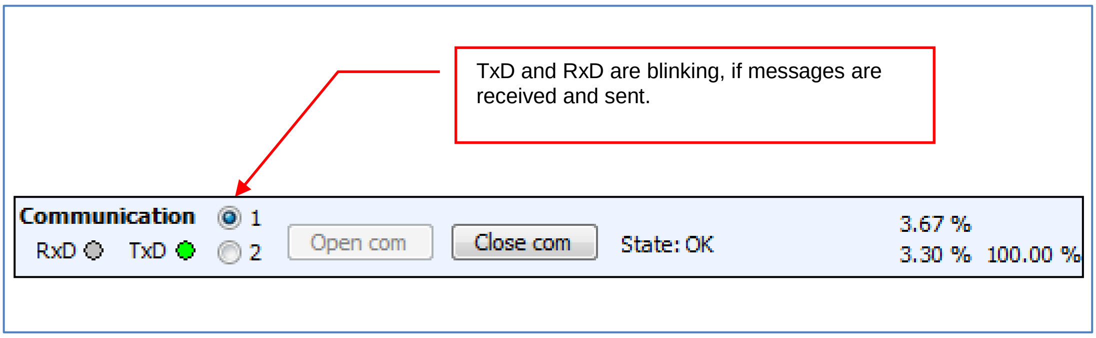

Figure 31 – CAN Communication: Select node to communicate

6.4.3 Trouble shooting

Symptom	*Solutions*
"State:Error:BUSHEAVY " is indicated	1. Verify if SKAI is running 2. Verify your CAN settings. Make sure node I_d and baud rate are correct. 3. Verify that the red LED of USB-PCAN Adapter is on. If it is off, check the driver installation or the USB port of the PC. 4. Close and Open the CAN communication and check again. 5. Open CAN communication and restart the SKAI. In the CAN Logger Window you should see the boot-up message of QUASAR indicating the correct Node I_d. If this message does not appear, verify the baud rate. 6. If a boot-up message from node I_d 0x10 was received, the Bootloader did not find a valid firmware. Program the firmware again.
"State: OK" is shown but actual values are not updated	Select "Send SYNC" option to activate the periodic update requests.

Table 20 – CAN communication trouble shooting

7 Setup Guide – Basic Settings

This chapter defines some configurations to be done to proceed with the step by step tutorial. These steps are prerequisites for the position sensor tuning.

7.1 Overview

Some basic motor and system parameters have to be defined and set in order the following steps give accurate results.

Manufacturers use different conventions in their motor specifications.

QUASAR uses the following values:

- Resistance and inductance values of a single phase winding
- Peak values for voltages and currents unless otherwise specified

7.2 Parameters

Parameter	***Typical value***	***Description***
Inverter Type [21A0]	n/a	
Inverter Subtype [21A1]	n/a	
Motor type [2119]	n/a	
Norm DC link voltage [2164]	n/a	Provide the DC-link voltage on which all p.u. indications will be based on
Warning minimal DC link voltage [2117]	n/a	
Minimal DC link voltage [2105]	n/a	
Warning maximum DC link generator voltage [2118]	n/a	
Maximum DC link voltage generator mode [210F]	n/a	
Maximum DC link voltage [2106]		
Maximum current motor [2100]	n/a	
Configuration hardware [2140]	n/a	Select interfaces to be used (Inputs, outputs, Sin/Cos Encoder input)
Motor temperature sensor type [214A]	n/a	Verify if correct motor temperature is indicated after configuring

Table 21 – Basic settings parameters

7.3 Motor and Sensor Information

To be able to use QUASAR, information about the connected components is very important. During evaluation it is important to define a system concept in order to be able to choose the appropriate SKAI type. This will facilitate and shorten the setup time considerably.

Values in datasheets of components may not be given in the same units as required by QUASAR. Especially values of motor parameters may be given in different units or may be provided as RMS values rather than peak values.

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8 Setup Guide – Position Sensor Setup

This chapter defines the procedure to configure the position sensors supported by QUASAR

8.1 Overview

The different sensor types require different setup steps. The following sections define the steps needed for each encoder type. Each of the steps is then described in the following chapters.

The following table shows which steps have to be completed for a given position sensor type.

Steps	*ABZ*	*ABZap*	*Sin/Cos*	*Resolver*
1. Type specific setup (see chapter 8.2) ○ Sin/Cos Encoder ○ ABZ Encoder ○ ABZap Encoder (with absolute position at start-up) ○ Resolver	x	x	x	x
2. Signal Offset / Gain Calibration (see chapter 8.2.2) ○ Scale signals for optimal use	-	-	x	-
3. Sense of rotation (see chapter 8.3)	x	x	x	x
4. Angle Offset Calibration (see chapter 8.4) ○ Configure difference between mechanical angles (from Encoder, depends on mounting) and electrical angle (given by windings of the motor)	x	x	x	x

Table 22 - Position sensor setup steps

The number of indexes per revolution must not be greater than the number of pole pairs of the motor.

The number of pole pairs of the motor divided by the number of indexes per revolution must result in a whole-number.

Both conditions must be true otherwise the position sensor is not suitable to be used with the motor.

8.2 Type Specific Setup

8.2.1 Incremental Encoder ABZ, ABZap and Resolver

8.2.1.1 Setup and Preconditions

- The motor is turned in forward direction using a test bench.
- The DC link voltage is switched off.
- Motor speed = 1-5% of maximum motor speed.
- Set *Encoder delay compensation [2169]* to 0.
- The phase cables must be connected and the phase sequence has to be in the correct order (u-v-w).

8.2.1.2 Criteria

Verify the saw tooth signal on the scope. Rising saw tooth = positive direction (see Figure 32).

8.2.1.3 Parameters

Parameter	***Typical value***	***Description***
Configuration hardware [2140]	0x00000000	Configure the following bits: 0000 0800: resets QEP counter on index if set to 1
Encoder type [2143]	1	1: incremental encoder
Number of encoder lines [2125]	n/a	Total number of **rising and falling** signal edges on track A and B. **Example:** Encoder with 1024 periods/revolution. → 2048 edges on track A + 2048 edges on track B → number of encoder lines = 4096
Encoder delay compensation [2169]	0	Set 0 when starting
Configuration incremental encoder [2113]	1	0000 0001: Enable encoder drift check
Encoder lines drift ignore limit [2114]	n/a	
Encoder lines drift error limit [2115]	n/a	
Encoder lines drift error count [2116]	5	
Indexes per mechanical revolution [2136]	1	The encoder may generate more than one index per revolution. Check its datasheet.

Table 23 – ABZ Encoder Parameters

ABZap specific:

Additional parameters for ABZap sensors are needed. This encoder type supports clocking out the current absolute position at start-up. Therefore the encoder power supply must only be switched after the SKAI is ready to handle encoder signals. Depending on the SKAI type, this feature is supported directly by selecting this encoder type. For other SKAI types this can be reached by connecting the encoder power supply to the Digital Output 1 of the SKAI.

Parameter	***Typical value***	***Description***
Configuration hardware [2140]	0x00000000	Usually Encoder power supply is used and not I/O)
Encoder type [2143]	4	Choose ABZap encoder type
Number of encoder lines [2125]	n/a	Make sure the correct value is set. Some manufactures use different line definition than QUASAR.

Table 24 – ABZap Encoder Parameters

Resolver specific:

The SKAI implements a conversion from analog resolver signals to digital ABZap Encoder Signals. Once initialized correctly, the Resolver works identically to the ABZap Encoder. Therefore only some special parameters must be given for the initialization. The rest of the setup is identical to the ABZ Encoder.

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Parameter	***Typical value***	***Description***
Encoder type [2143]	6	Choose encoder type Resolver
Number of encoder lines [2125]	4096	This value must be set for resolver.
Configuration resolver [2144]	0x0A29	12 bit resolution (0x0Axy)
Resolver transformation ratio [2175]	n/a	Depending on transformation ratio of the resolver.
Indexes per mechanical revolution [2136]	2p motor	Enter the number of pole pairs of the resolver.

Table 25 – Resolver Parameters

8.2.1.4 Scope Settings

- EncoderLines.ssf

8.2.1.5 Procedure

- Before starting the setup; make sure the parameters have the correct values; especially the Number of Encoder Lines.
- Load the Scope setting file and check the angle signal. If the angle is rising; this means that the direction of the motor is positive.
- Check the direction of rotation.

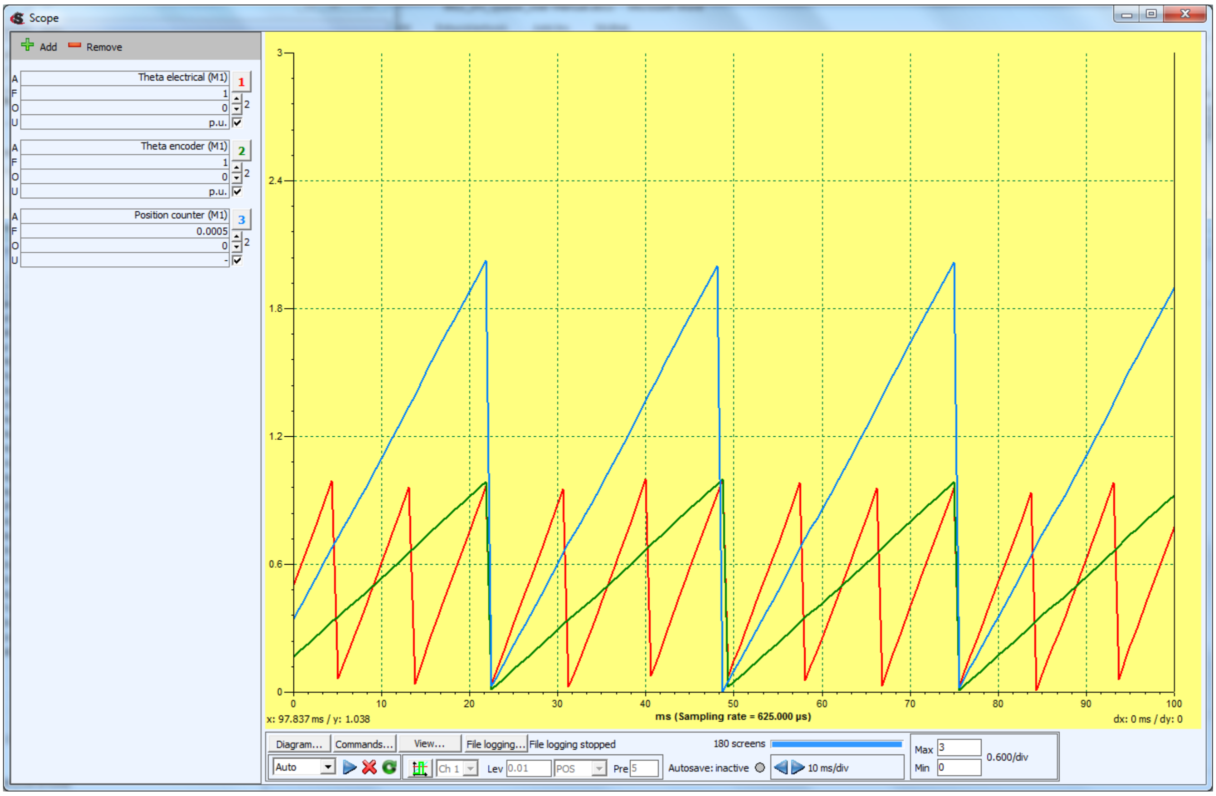

Figure 32 – Positive Rotation Direction (3 pole pairs, 1 index per revolution)

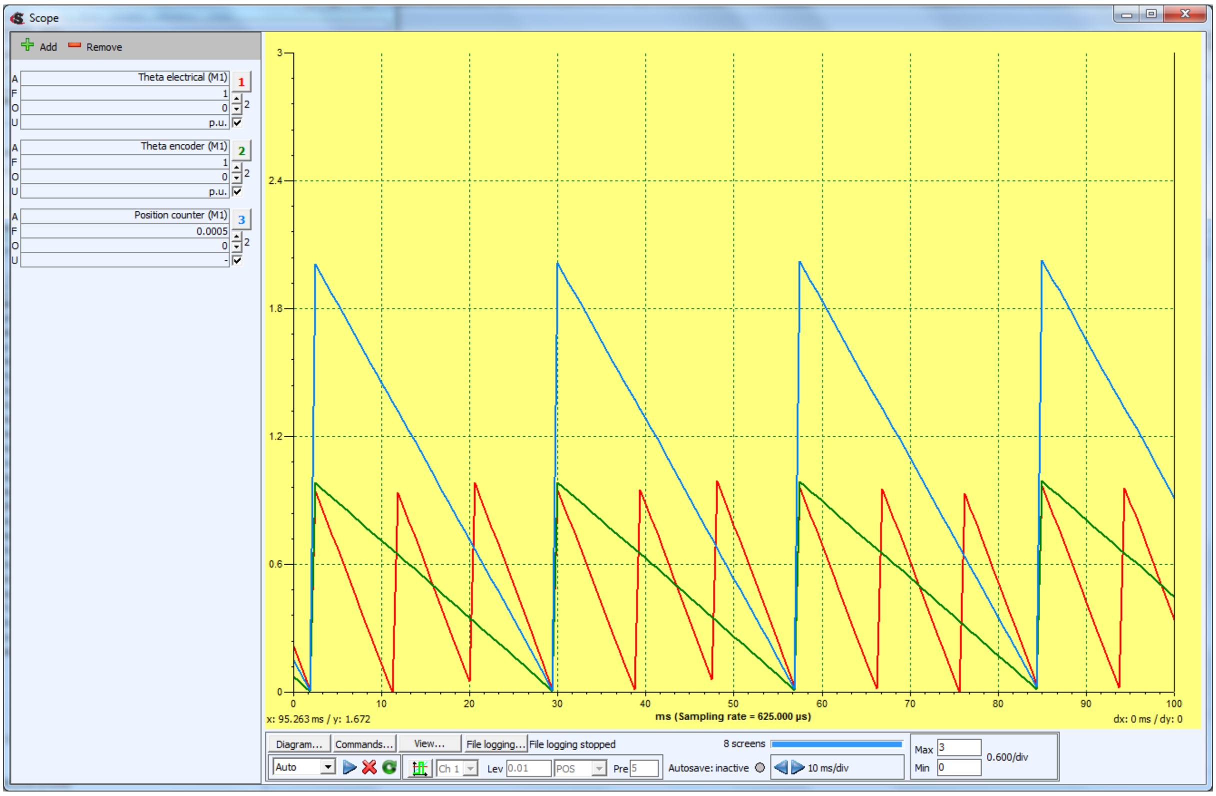

Figure 33 – Negative Rotation Direction (3 pole pairs, 1 index per revolution)

8.2.2 Sin/Cos Encoder

The Sin/Cos encoder delivers analogue signals indicating the absolute rotor position. In order to enable QUASAR determining the position correctly the received signals have to be scaled using an offset and gain.

The offset correction of sine and cosine signals is used to achieve symmetrical signals. The gain correction of sine and cosine signals is used to achieve a signal range of [-1; +1].

8.2.2.1 Setup and Preconditions

- No DC link voltage required.
- The motor is turned in forward direction using a test bench. Motor speed = 1-5% of max. motor speed.
- Set *Encoder delay compensation [2169] to* 0
- Set *Sin/Cos encoder cosine gain [212C]* and *Sin/Cos encoder sine gain [2133]* to 1
- Set *Sin/Cos encoder cosine offset [212E]* and *Sin/Cos encoder sine offset [212D]* to 0

8.2.2.2 Criteria

Sine and cosine signals are called to one and do not have any DC offset.

8.2.2.3 Parameters

Parameter	***Typical value***	***Description***
Configuration hardware [2140]	0x00080000	Select the analogue inputs to which the Sin/Cos encoder signals are connected to
Encoder type [2143]	2	
Encoder delay compensation [2169]	0	Set 0 when starting to configure
Sin/Cos encoder cosine offset [212E]	n/a	To be determined using the procedure described below.

Sin/Cos encoder cosine gain [212C]	n/a	To be determined using the procedure described below.
Sin/Cos encoder sine offset [212D]	n/a	To be determined using the procedure described below.
Sin/Cos encoder sine gain [2133]	n/a	To be determined using the procedure described below.
Filter constant for sine input [2184]	0	Filter is not active
Filter constant for cosine input [2185]	0	Filter is not active

Table 26 – General Encoder Parameters

8.2.2.4 Scope settings

- SinCosEncoderGainOffset.ssf

8.2.2.5 Procedure

There are different ways to define the gain and the offset values. One is to change the values of gain and offset manually until the signals are scaled appropriately.

The second and recommended possibility is to save the values measured in the scope to a csv file and calculate the gain and offset using the SinCos worksheet of Setup Calculation Excel file (refer to [3]).

1. Measure original curves
2. Save data to csv
3. Open the received file in Excel
4. Copy columns E and F into column B and C of the calculation sheet
5. Copy the received values in the Q-Control Parameter window
6. Reset the node
7. Verify the result and make manual tuning if necessary.

The excel file used the following formulas to calculate gain and offset:

- Calculate gain= $2/(V_{max} - V_{min})$
- Calculate offset = $(V_{max} + V_{min})/2$

The following figure shows the result that should be seen in the scope after successful calibration:

- Light green and orange: raw signals of the Sin and Cos track
- Green and red: Sin and Cos track signals after gain/offset correction
- Blue: Resulting electrical angle signal (Positive rotating direction, 4 pole pairs)

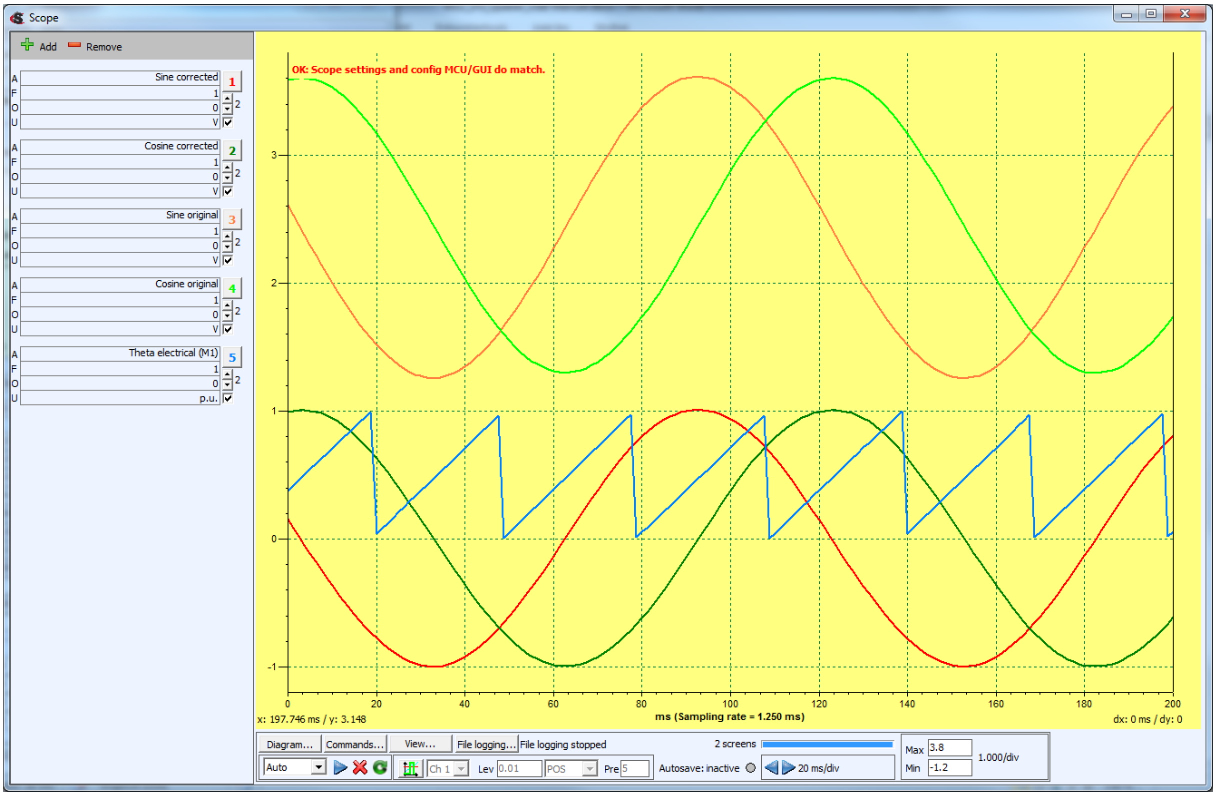

Figure 34 – Sin/Cos Encoder Offset

8.3 Sense of Rotation and Phase Sequence

For the motor to actually start and turn in a specific direction, the sense of the rotation given by the position sensor must match with the sense of the windings of the motor. Furthermore the connection sequence of the motor windings at the SKAI inverter terminals must be correct

8.3.1 Setup and preconditions

- DC link voltage on.
- Speed reference value 10% of maximum motor speed.
- Torque reference value 0%.
- PWM enabled.
- Make sure to set parameter *Norm DC link voltage [2164]* to nominal DC link voltage.

8.3.2 Criteria

- Motor must start if the sense of the position sensor matches with the phase sequence.

8.3.3 Parameters

Parameter	***Typical value***	***Description***
Configuration hardware [2140]	0x00000000	Configure the following bits: 0000 0100: motor direction 0000 0200: change phase sequence v = w, w = v 0000 0400: change counting sequence from encoder Do only change one parameter at once.

Table 27 – Parameters for sense of rotation

8.3.4 Procedure

First the sense of rotation must be adjusted.

1. Rotate the motor in the direction you define a forward by using the test bench or by hand
2. If the indicated speed is positive, the setting is ok
3. If the indicated speed is negative, change the Motor direction bit.

Now it can be checked if the phase sequence matches with the sense given by the position sensor.

There is also a more practical way to tune the phase sequence defined below.

At this point of setup the motor can be operated at low current and therefore to find if the rotating sense does match, the motor can be started for the first time.

1. Limit the speed to 10% of maximum motor speed by setting the speed reference value.
2. Enable PWM.
3. Set the torque reference value to 2%.
   → If the motor starts, the sequence is OK.
4. If the motor does not start, increase the torque set point to 4%.
   → If the motor starts the sequence is OK.
5. If the motor does still not start change the phase sequence in the parameters.

With the actual setup, QUASAR may not be able to control the motor correctly. If the motor starts, it may accelerate to speeds above the value given as maximum reference.

Be ready to turn off the system manually or make sure the maximum motor speed is set to 10% of maximum motor speed or 500rpm respectively.

8.4 Encoder Angle Offset Calibration

The purpose of this step is to find the angle difference between the magnetic field of the rotor and the encoder zero position.

For the ACIM motor the absolute position is not needed. Therefore the angle offset calibration described in this chapter can be skipped.

8.4.1 Setup and Preconditions

- Make sure to set parameter “Norm DC link voltage [2164]” to nominal DC link voltage.
- Set *Encoder delay compensation [2169]* to 0.
- DC link voltage must be on.
- Torque reference value 0%.
- PWM enabled.
- Motor rotates at NO load (driven by test bench or driven by motor).
- Set the motor speed to reach U_{dq} = 10% (increase speed and verify U_{dq} actual value given in Q-Control).
- The Cooling system must be on.

8.4.2 Criteria

- The found angle offset is correct if the measured value of U_d (U_d close to 0) is the same in both rotating directions at the same speed.

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8.4.3 Parameters

Parameter	Typical value	Description
Encoder angle offset [2123]	n/a	0..1 = 0..360°mech e.g. motor with 4 pole pairs: 0..0.25 = 0..360°el

Table 28 – Encoder Offset Calibration Parameters

8.4.4 Scope Settings

- PositionSensorAngleOffset.ssf

8.4.5 Procedure with Test Bench

1. Load the Scope Settings File and set the parameter Encoder Delay Compensation = 0.
2. Drive the motor in the positive rotating direction.
3. Adjust the Index Angle Offset parameter until $U_d = 0$

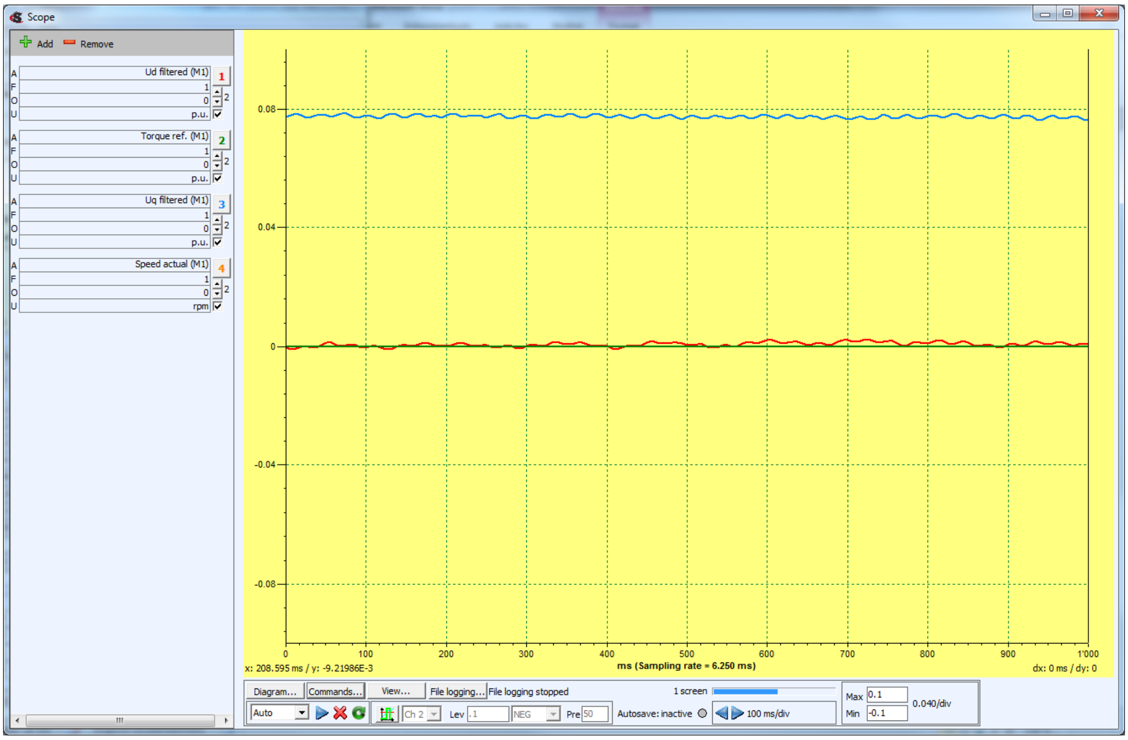

Figure 35 – Encoder angle offset calibration

Check that U_q has the same sign as the rotating direction. If this is not the case, then the angle offset is more than 180°.

U_d and U_q must not cross 0 when oscillating but must have a respective DC offset. If this is not the case check the phase sequence (Configuration hardware [2140]) and Pole pairs [2124].

4. Change motor direction at the same speed and adjust the Index Angle Offset parameter until $U_d = 0$.
5. Repeat step 1-4 in the opposite direction several times.

For fine tuning you may also run the automatic calibration function provided in the Q-Control main window in *Command→Start encoder offset calibration.* Start it several times and check the result (Only working with test bench).

8.4.6 Procedure without Test Bench

The procedure without test bench is less straight forward and may not result in as accurate results as with a test bench.

1. Make sure the trigger is set to the Torque ref on channel 2 with negative edge and a level of 0.1. Select single or normal mode.
2. Set the parameter Encoder Delay Compensation = 0.
3. Accelerate motor in the positive rotating direction.
4. When speed is reached where U_{dq} = 10% , change the torque reference value to 0%.
5. Scope will trigger on the falling edge of the reference value torque.
6. Change the angle offset to get U_d = 0 V.

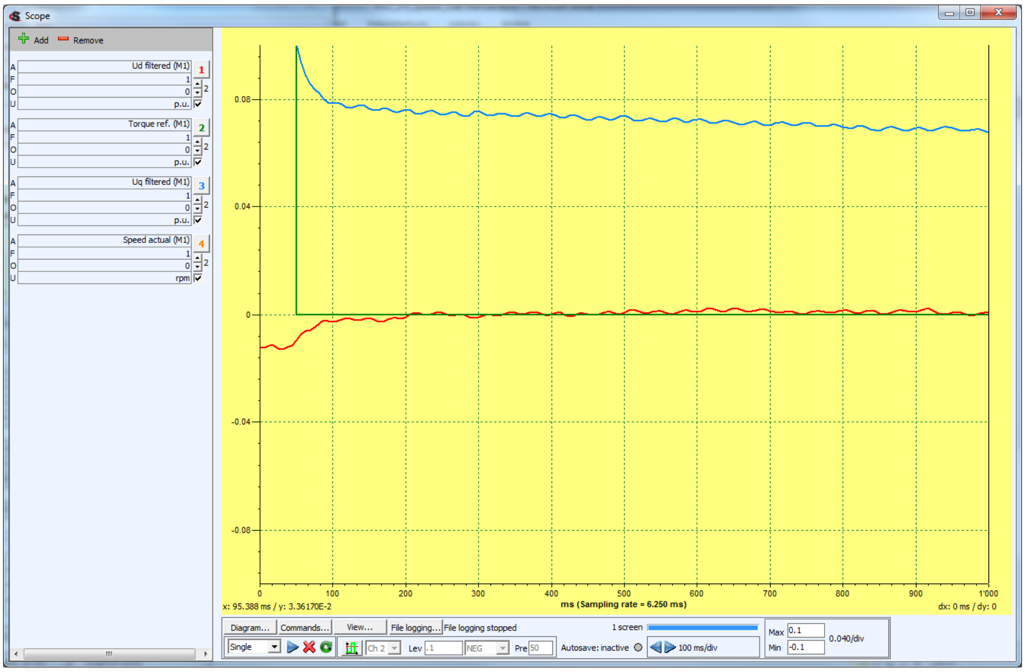

Figure 36 – Encoder angle offset calibration without test bench

7. Repeat step 1-6 in the opposite direction several times.

Please verify calibration after tuning the current controllers.

9 Setup Guide – Limits and Cutbacks

The system will shut down or reduce speed or torque at the limits and therefore avoid damages. For safety reasons it is highly important to set the limits correctly and enable the desired limitations.

The safety parameters can be set in the Safety Limits parameter window of Q-Control (Menu View : Parameters).

9.1 Setup and Preconditions

- Q-Control is running
- Communication with the SKAI is working

9.2 Procedure

The procedure is to set the values of the implemented safety functions to values defined by the system.

9.3 Acceleration Torque Limiter

This task allows limiting the acceleration torque. The limitation is activated, if the torque limiter is enabled in the Configuration parameter.

Parameter	***Typical value***	***Description***
Acceleration limit start [216C]	n/a	Set high acceleration to disable (e.g. 10000 $^{rad}/_{s^2}$)
Maximum acceleration [216D]	n/a	Set high acceleration to disable (e.g. 10000 $^{rad}/_{s^2}$)
Acceleration calculation filter [215C]	0.01	Acceleration filter time constant
Configuration vector control [2150]	0x00080FFD	All limiters active

Table 29 – Acceleration torque cutback limiter parameters

9.4 Power Limiter

If the power limiter is enabled it is not possible to generate more power than the specified value. The system will reduce torque to hold the limit.

9.4.1 Parameters

Parameter	***Typical value***	***Description***
Maximum power [2145]	n/a	
Configuration vector control [2150]	0x00080FFD	All limiters active

Table 30 – Simple power limiter parameters

9.4.2 Motor Temperature Limiter

The Motor temperature limiter is implemented as a Maximum Cutback Limiter as defined in 3.9.3.1.

Parameter	Typical value	Description
Warning motor temperature [2109]	See motor specification	Maximum cutback limiter warning level
Maximum motor temperature [210A]	See motor specification	Maximum cutback limiter error level
Configuration vector control [2150]	0x00080FFD	All limiters active

Table 31 – Motor temperature cutback limiter parameter

9.4.3 Power Electronics (DCB) Temperature Limiter

The DCB temperatures are the temperatures measured on the DCB (direct copper bonded) substrate close to the position of the power semiconductor switches (DCB 1 temp: phase 1, DCB 2 temp: phase 2, DCB 3 temp: phase 3). The highest temperature value is used for the DCB temperature limiter.

The DCB temperature limiter is implemented as a Maximum Cutback Limiter as defined in 3.9.3.1.

Parameter	Typical value	Description
Warning DCB temperature [210B]	See SKAI datasheet	Maximum cutback limiter warning level
Maximum DCB temperature [210C]	See SKAI datasheet	Maximum cutback limiter error level
Configuration vector control [2150]	0x00080FFD	All limiters active

Table 32 – DCB Temperature Limiter

9.4.4 PCB Temperature Limiter

The electronic temperature is measured directly on the printed circuit board (PCB).

The PCB temperature limiter is implemented as a Maximum Cutback Limiter as defined in 3.9.3.1.

Parameter	Typical value	Description
Warning PCB temperature [2107]	See SKAI datasheet	Maximum cutback limiter warning level
Maximum PCB temperature [2108]	See SKAI datasheet	Maximum cutback limiter error level
Configuration vector control [2150]	0x00080FFD	All limiters active

Figure 37 – PCB Temperature Limiter Parameters

9.4.5 Minimum DC Link Voltage Limiter

The Minimum DC Link Voltage is implemented as a Minimum cutback limiter as defined in 3.9.4.

The limiter is used to avoid deep discharge of a battery connected to the DC Link and for SKAI LV types it ensures that the internal DC/DC converter, providing the PCB power supply, can operate within the specified range.

The minimum critical value is typically set about 5% above the absolute minimum value.

Parameter	Typical value	Description
Warning minimal DC link voltage [2117]	n/a	Minimum cutback limiter warning level
Minimal DC link voltage [2105]	n/a	Minimum cutback limiter error level
Configuration vector control [2150]	0x00080FFD	All limiters active

Figure 38 – Minimum DC Link Voltage Cutback Limiter Parameters

9.4.6 Maximum DC Link Voltage Limiter

The Maximum DC Link Voltage is implemented as a Maximum cutback limiter as defined in 3.9.3.1.

The limiter is used to protect the SKAI and the power supply (e.g. battery) connected to the DC link. Therefore the value of the absolute maximum is limited to the SKAIs maximum voltage.

The maximum critical voltage is typically set about 3% below the absolute maximum value.

Parameter	***Typical value***	***Description***
Warning maximum DC link generator voltage [2118]	n/a	Maximum cutback limiter warning level
Maximum DC link voltage generator mode [210F]	n/a	Maximum cutback limiter error level
Configuration vector control [2150]	0x00080FFD	All limiters active

Table 33 – Maximum Battery Voltage Parameters

9.4.7 Speed Limiter

This feature allows limiting the speed of the motor. If the limiter is activated, it is not possible to run at a higher speed than the defined maximum speed in motor mode. The speed limiter is not active in generator mode.

The speed limiter is implemented as a Maximum cutback limiter as defined in 3.9.3.1.

Parameter	***Typical value***	***Description***
Warning speed [2104]	n/a	Maximum cutback limiter warning level
Maximum speed [2102]	n/a	Maximum cutback limiter error level
Speed filter constant PT2 [213A]	0.05	Speed filter time constant
Configuration vector control [2150]	0x00080FFD	All limiters active

Table 34 – Speed Limiter Parameters

10 Setup guide – Motor Control Settings

If the previous steps have been completed, the SKAI with QUASAR is almost ready for operation. What is missing is the tuning of the motor control for the motor to be used. This will make sure the motor will run at high efficiency in every operating point.

10.1 PSM/IPM Settings

10.1.1 Current Controller

This procedure provides setup of the current controllers. This test is done with step responses at different current values. The gain K and KI parameters of the controllers are adjusted until the step response has a fast rise without overshoot.

The gains for K_p and T_n may decrease in function of the current and reach a minimal value at a certain limit. Therefore the I_d and I_q controller have some parameters to adjust this non-linear gain behavior.

Non linear gains can also be deactivated if not needed. To do so see chapter 10.1.2.

10.1.1.1 Setup and Preconditions

- Make sure that angle is correct (angle offset is correct, encoder has been referenced).
- Block the motor shaft.
- Apply nominal DC link voltage.
- Disable Iqref Filter and Dead Time Calculation in *Configuration vector control [2150]*
- Set *Configuration Id current control [2195]* = 0x00000000
- Set *Configuration Iq current control [2190]* = 0x00000000
- Set start values for K_p and T_n given in Table 35.

10.1.1.2 Parameters

Parameter	***Typical value***	***Description***
Configuration vector control [2150]	0x00080FFD	Value 0x00000009 must be set in order to disable filters for the tuning Set back to typical value after completing this step.
Configuration Id current control [2195]	0x00000001	Disable all options and set back to typical value after completing this step.
Gain Kp Id current control [2138]	n/a	Start value K_p = 0.0005
Time constant Tn Id current control [2139]	n/a	Start value T_n = 0.003
Non linear gain corner current Kp (Id) [2196]	n/a	Result of this step
Non linear gain Kp slope (Id) [2197]	n/a	Result of this step
Non linear gain corner current Tn (Id) [2198]	n/a	Result of this step
Non linear gain Tn slope (Id) [2199]	n/a	Result of this step
Configuration Iq current control [2190]	0x00000001	Disable all options and set back to typical value after completing this step.

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Parameter	***Typical value***	***Description***
Gain Kp Iq current control [2134]	n/a	Start value K_p = 0.0005
Time constant Tn Iq current control [2135]	n/a	Start value T_n = 0.003
Non linear gain corner current Kp (Iq) [2191]	n/a	Result of this step
Non linear gain Kp slope (Iq) [2192]	n/a	Result of this step
Non linear gain corner current Tn (Iq) [2193]	n/a	Result of this step
Non linear gain Tn slope (Iq) [2194]	n/a	Result of this step

Table 35 – I_d/I_q current control parameters PSM

10.1.1.3 Scope settings

- IdCurrentController.ssf
- IqCurrentController.ssf

10.1.1.4 Procedure

The current controller for I_d and I_q will be tuned separately. Therefore the procedure is split into two main steps.

K_p and T_n will be determined for different operating points. These values can be filled into the worksheets I_d and I_q in the Setup Calculation file (see [3]). Follow the steps defined in the worksheet to make a linear interpolation and to find the required configuration values.

After configuring the current controller, verify the Encoder Angle Offset as described in chapter 8.3 and adapt it if necessary.

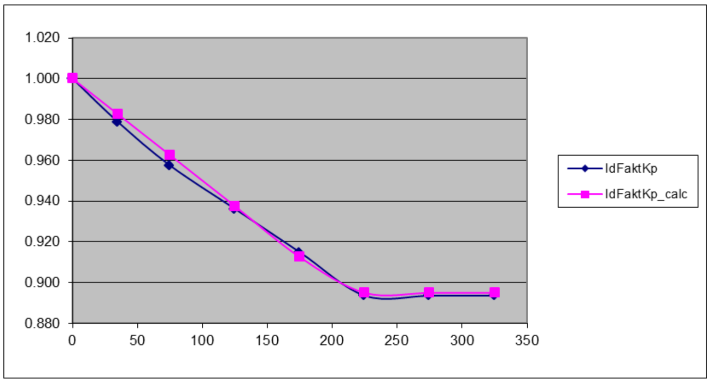

Figure 39 - Example for K_p-Factor interpolation

Procedure for I_q Current Controller

1. Using Automatic Test Mode (refer to [2]) make a step of current following the example below. The initial current step should start from near zero to approximately 10% of maximum motor phase current.

Time [0.1s]	Current [A] / Torque [%]	Speed [Rpm]	***Mode*** ***0x01 : on*** ***0x02 : Speed*** ***0x03 : I_q/I_d mode***	Current Angle [°]
2	0	500	3	0
2	5	500	3	0
2	25	500	3	0
2	5	500	3	0
2	0	500	3	0

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Table 36 – Example automatic test mode file for I_q current step

2. Increase (or decrease) the gain (K_p) to reach 80% of reference value
3. Repeat step 1 and 2 until K_p is tuned correctly
4. Again run the same automatic test file as before
5. Now increase (or decrease) T_n
6. Repeat step 4 and 5 until the response of the controller looks more or less as in the figure below.

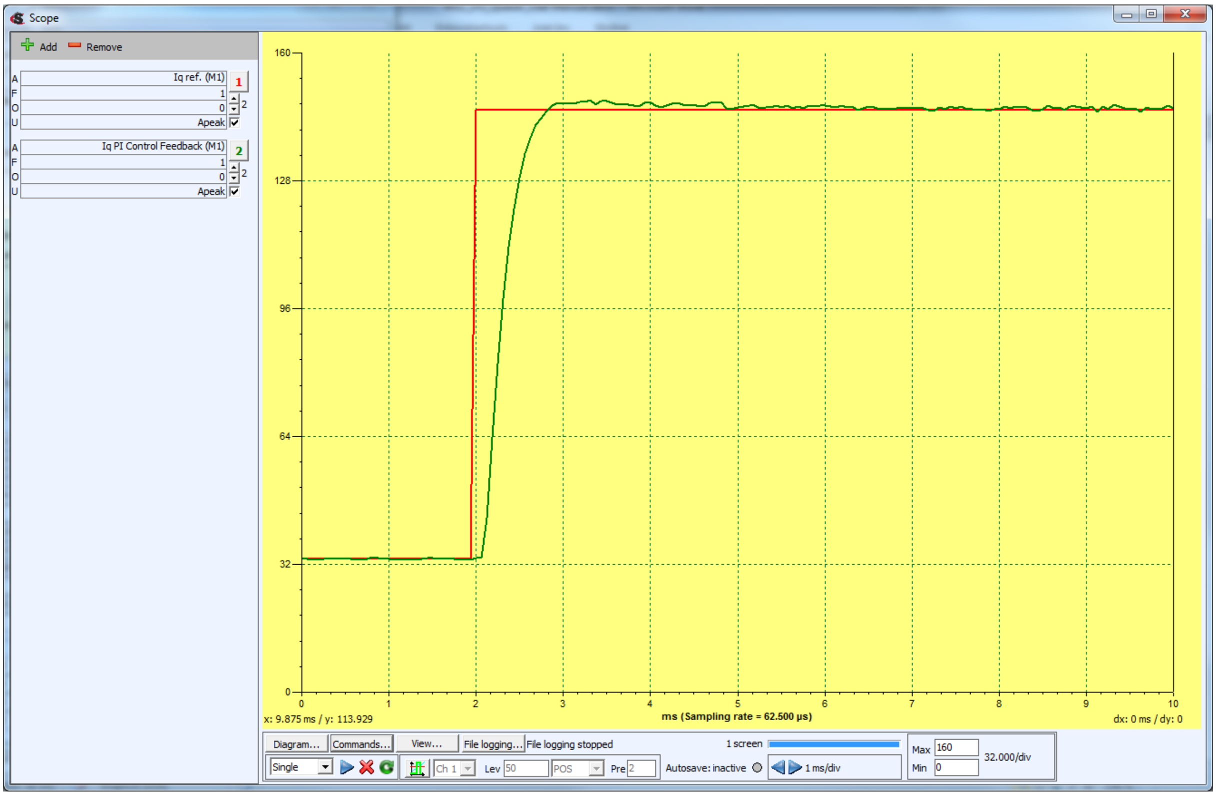

Figure 40 – I_q controller step response tuning

7. Now repeat step 1 to 6 for different current steps from 0 to 20% to 40% of maximum motor phase current

Procedure for I_d Current Controller

Follow the same procedure as described in the previous chapter but do it with the I_d currents. Therefore set the angle value in the Automatic Test mode file to 90° and vary the value of K_p and T_n for the I_d current controller parameters.

Instead of Triggering on channel 1 (I_q ref) trigger on channel 3 (I_d ref) negative (falling) edge.

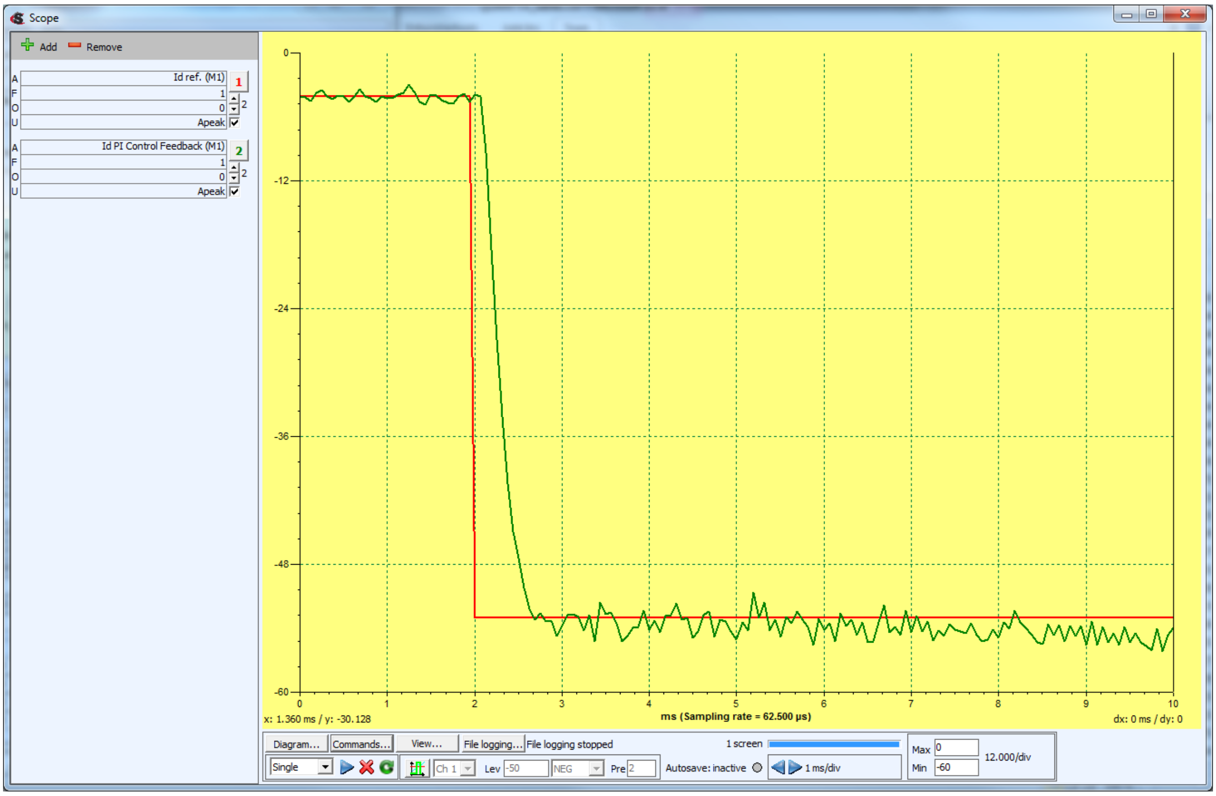

Figure 41 – I_d controller step response tuning

After configuring the current controller, verify the Encoder Offset as described in chapter 8.3 and adapt it if necessary.

After the current controller setup has been completed activate the Iq_{ref} Filter in the *Configuration vector control [2150]* parameter. (Typical: 0x00080FFD)

10.1.2 Current controller without non linear gains

Some motor may not need non linear gains, because K_p and T_n are constant. Therefore measurements only have to be done at one operating point with nominal current. Therefore the Setup Calculation excel file (refer to [3]) is not needed. The found values are directly filled in the K_p and T_n parameters for I_d and I_q.

10.1.2.1 Parameters

Parameter	*Typical value*	*Description*
Configuration vector control [2150]	0x00080FFD	Value 0x0000009 must be set in order to disable filters for the tuning Set back to typical after completing this step.
Configuration Id current control [2195]	0x00000000	Disable non linear gains
Gain Kp Id current control [2138]	n/a	Start value K_p = 0.0005
Time constant Tn Id current control [2139]	n/a	Start value T_n = 0.003
Configuration Iq current control [2190]	0x00000000	Disable non linear gains
Gain Kp Iq current control [2134]	n/a	Start value K_p = 0.0005
Time constant Tn Iq current control [2135]	n/a	Start value T_n = 0.003

Table 37 – I_d/I_q current control parameters PSM

10.1.3 Encoder Delay Compensation

This step is actually a part of the encoder configuration. As it is part of the fine tuning, it does not make sense to carry out this step before the current controller has been tuned and the encoder offset has been adjusted again afterwards.

Encoder delay compensation allows compensating phase lag effects of analogue encoder systems at higher motor speeds. It is important to do first the position sensor calibration described in chapter 8.4 before doing this setup.

In general the procedure is the same as to determine the angle offset. The only difference is that the procedure is done at higher motor speed.

10.1.3.1 Setup and Preconditions

- Test bench in speed controlled mode with maximum torque.
- DC link voltage must be on
- Torque reference value 0%.
- PWM enabled.
- Motor rotates at NO load (driven by test bench or driven by motor).
- Set the motor speed to reach U_{dq} = 40%.

10.1.3.2 Criteria

- U_d = 0 if torque reference value is 0.

10.1.3.3 Parameters

Parameter	*Typical value*	*Description*
Encoder delay compensation [2169]	0.000006	

Table 38 – Encoder delay compensation parameter

10.1.3.4 Scope Settings

- PositionSensorAngleOffset.ssf

10.1.3.5 Procedure with Test Bench

Follow the procedure in chapter 8.4.5 but modify the Delay Compensation parameter instead of the Encoder Offset.

10.1.3.6 Procedure without Test Bench

Follow the procedure in chapter 8.4.6 but modify the Delay Compensation parameter instead of the Encoder Offset.

10.1.4 Generator Constant (k_g)

This step defines how to check for correct phase sequence and that the generator constant (k_g) corresponds to the actual setup.

10.1.4.1 Setup and Preconditions

The motor is driven in forward direction using a test bench. Each of the three motor phases must be connected by a 1kOhm resistor to a virtual star point (GND for oscilloscope).

The motor phases must **NOT** be connected to the inverter outputs L1, L2, L3.

There must not be a connection from the motor phases to the inverter L1, L2, L3!

- No connection from the motor phases to the inverter.
- Motor speed 5-10% of maximum motor speed.
- Phase sequence checked with oscilloscope.
- Induced voltage rms value can measured with a multi-meter
- Ambient temperature 25 C

10.1.4.2 Criteria

- Sinusoidal open terminal voltages on all motor phases with similar amplitudes.
- Phase sequence U-V-W = L1-L2-L3 when turning in forward direction, otherwise phase sequence has to be changed by using the respective flag in parameter *Configuration hardware [2140]*.
- Find or verify number of pole pairs by comparing test bench speed and fundamental frequency of induced voltage

10.1.4.3 Parameters

Parameter	***Typical value***	***Description***
Configuration hardware [2140]	0x00000000	Change phase sequence if needed. Use flag 0x00000200.
Generator constant [2120]	n/a	Calculated in this step
Pole pairs [2124]	n/a	According to motor datasheet

Table 39 – Induced Voltage Test Parameters

10.1.4.4 Procedure

Example results:

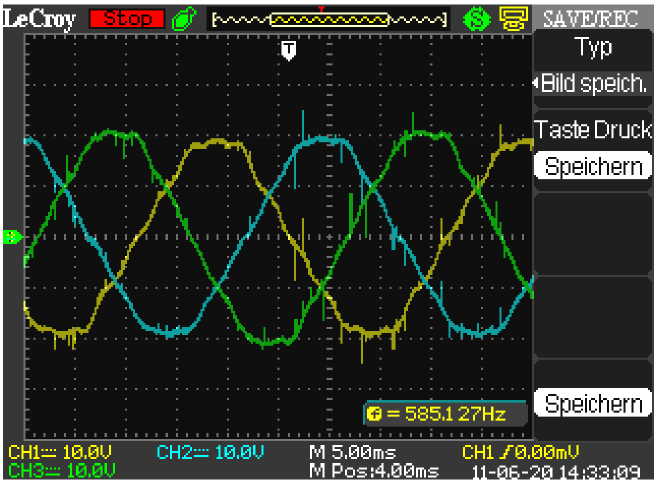

Figure 42 – Induced Voltage Example

- Ch1: Voltage phase U–V
- Ch2: Voltage phase V-W
- Ch3: Voltage phase U-W

The measured value is added in the worksheet k_g in the Setup Calculations Excel file (see [3]) to calculate the generator constant correctly.

Voltage between	*Result*	*Unit*
PhaseU-PhaseV	24.26	[Vrms]
PhaseV-PhaseW	24.26	[Vrms]
PhaseU-PhaseW	24.26	[Vrms]
Resulting k_g	0.3783	[Vpeak/rad/s]
Resulting k_g	0.04852	[Vrms/rpm]

Table 40 – Induced voltage example

10.1.5 Phase Resistance Measurement

Check if the motor’s stator phase resistance corresponds to the design.

The phase resistance shall include the resistance of the connecting power cables

10.1.5.1 Setup and Preconditions

- Phase resistance with U/I method.
- Amperemeter: For example Hewlett Packard 974A 4½ Digit True RMS multi-meter.
- Voltmeter: For example Fluke 289 True RMS multi-meter.
- Constant current trough motor windings supplied by a laboratory power supply.

10.1.5.2 Parameters

Parameter	***Typical value***	***Description***
Stator resistance [2121]	n/a	According to datasheet or measured including cabling.

Table 41 – Motor resistance parameters

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10.1.5.3 Procedure

1. Measure the values as shown in Table 42.
2. Fill the values in the setup calculations excel sheet [3] and configure the respective parameter with the calculated value.

Example results:

	Phases U-V	Phases V-W	Phases W-U	Phase, mean
I_const [A]	4.725	4.725	4.724	
U_drop [V]	0.1485	0.14805	0.1465	
R [mΩ]	31.4285714	31.3333333	31.0118544	**15.62895985**

Table 42 – Phase Resistance Calculation

Remarks:

The phase resistance was specified with:

- 12.8mΩ @ 20°C winding temperature
- 20mΩ @ 160°C winding temperature

10.1.6 Field Weakening PSM/IPM

In field weakening I_d current is added to reduce the induced voltage of the motor to be able to still generate some torque.

10.1.6.1 Setup and Preconditions

- The test bench shall drive the motor with a speed just below the field weakening point. ($U_{dq\text{-}abs}$ around 80%).
- Enable PWM.

10.1.6.2 Parameters

Parameter	Typical value	Description
Maximum absolute value of current (FW) [2142]	n/a	Maximum absolute value of current in A_{peak}
Udq absolute vector length 1 (FW) [214B]	0.92	First U_{dq}Abs corner point
Udq absolute vector length 2 (FW) [2162]	0.94	Second U_{dq}Abs corner point
KFact FW control limit 1 [214C]	0.05	Cutback factor above first corner point
KFact FW control limit 2 [2163]	0.4	Cutback factor above second corner point. This typically is 8 times “KFact for FW Control”
Maximum value for Id (FW) [214D]	0.95	Max. I_d value of current in % of max. Absolute value of current
Udq absolute vector maximum length [215F]	0.97	Hold PI controller integrator
D-Factor for Iq limitation in f(UdqAbs) [2160]	0	Set 0. Feature normally not needed.
Start Iq limitation in f(UdqAbs) [2161]	0.72	Ignored if *D-Factor for Iq limitation in f(UdqAbs) [2160]* is set 0
Norm DC link voltage [2164]		Choose values depending on motor type. PSM: Voltage of normal operation IPM: Voltage lower than normal operation$^{1)}$

Table 43 – Field Weakening Parameters

[1)] For IPM motor I_d generated from a specific speed defined in the IPM motor characteristic tables. Therefore it is possible that the field weakening effect is not visible with the test above. To tune field weakening for IPM motors set the parameter of the *Norm DC link voltage [2164]* to a smaller value. This will result in lower automatically generated I_d and allows having a similar condition as with a PSM.

A good approach to choose the *KFact FW control limit 2 [2163]* is to multiply *KFact FW control limit 1 [214C]* with 8.

$$\frac{KFact\ for\ FW\ Control\ Limit\ 2}{\text{KFact for FW Control Limit 1}} = 8$$

10.1.6.3 Scope Settings

FieldWeakening.ssf

10.1.6.4 Procedure

1. Enable PWM.
2. Make a torque step and record it with the scope.
3. Changes of KFact should not affect the captured signals.
4. Make sure the speed is just at the beginning of the field weakening region and with the torque step the motor is already in the field weakening region. $U_{dqAbsFiltered}$ > U_{dq} Absolute Vector length1
5. If the field weakening is working, I_d will be generated, if $U_{dqAbsFiltered}$ is higher than the parameter Udq absolute vector length 1 (FW) [214B]
6. Set KFact as high as possible without inducing oscillations in the measured currents.
7. Repeat steps 3 and 6 at different speed until the FW reacts as fast as possible without oscillations.

Example:

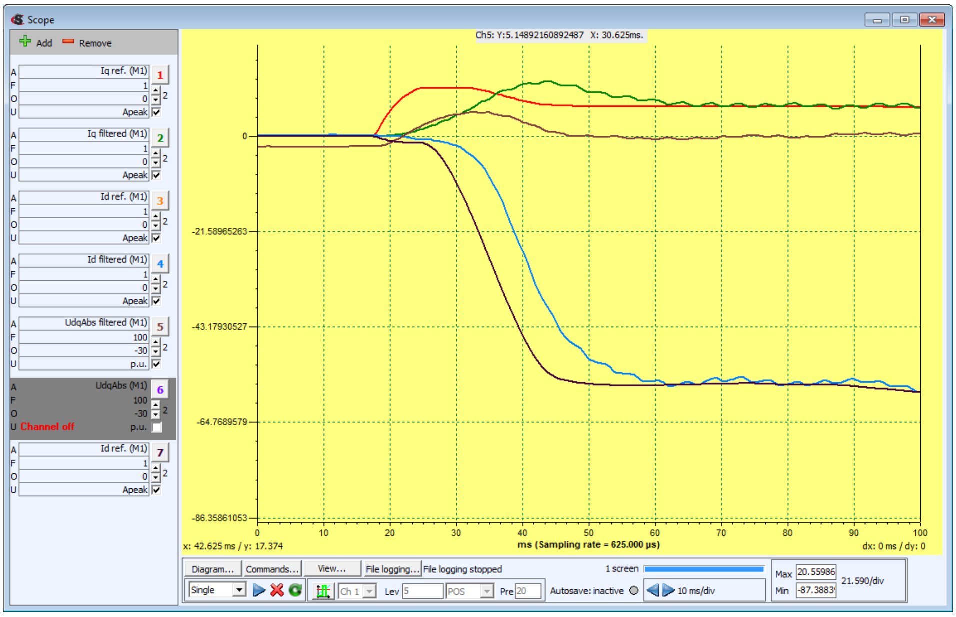

Figure 43 – Field Weakening Tuning

10.1.7 Non Linear State Feedback (NLSF)

In this step non NLSF is configured. If the feature is not used, it can be disabled using the respective parameter.

10.1.7.1 Setup and Preconditions

- Activate the NLSF in the *Configuration vector control [2150]* parameter.

- Enable PWM
- Set test bench speed to 10% of maximum motor speed.

10.1.7.2 Parameters

Parameter	*Typical value*	*Description*
Configuration vector control [2150]	0x00080FFD	Enable NLSF (flag 0x00001000)
Ld [2165]		Value of the Ld
Lq [2166]		Value of the Lq
Generator constant [2120]		Value of the generator constant

Table 44 – NLSF Parameters

10.1.7.3 Scope Settings

- NLSF.ssf

10.1.7.4 Procedure

1. Set the parameters L_d/L_q and generator constant with the correct values of the motor and activate the NLSF in parameter *Configuration vector control [2150]*.
2. Use Q-Control test function "current regulator", set 25-50% of maximum motor current as amplitude at 0 degrees current angle (pure q-axis current). Modify L_q in order the value for U_d before NLSF adaption (Variable *Ud control output* in NLSF.ssf) shows the same value as if no current is applied. Increase test bench speed and repeat the procedure above to generate an array of L_q = f(omega).
3. Use Q-Control test function "current regulator", set 25-50% of maximum motor current as amplitude at 90 degrees current angle (pure d-axis current). Modify L_q in order the value for U_q before NLSF adaption (Variable *Uq control output* in NLSF.ssf) shows the same value as if no current is applied. Increase test bench speed and repeat the procedure above to generate an array of L_d = f(omega).

For IPM motors L_d and L_q are not constant. Therefore the procedure should be repeated in several operating points if the motor characteristics are not known.

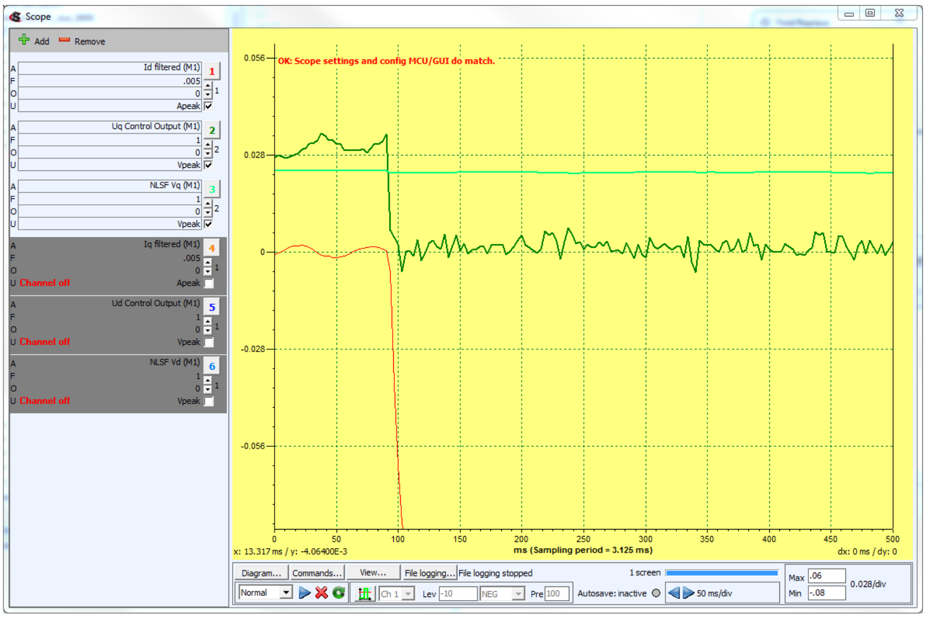

Figure 44 – Id current step with tuned and enabled NLSF

10.2 ACIM Settings

This chapter defines the specific steps to configure QUASAR to control an AC induction motor.

10.2.1 Basic Motor Parameters

Using the datasheet of the motor manufacturer, the different parameters (like R_s, R_r, $L_{\sigma s}$ …) can be inserted in the Q-Control parameter editor. If these parameters are unknown, the conventional tests can be done to try to obtain a good approximation of them.

Parameter	***Typical value***	***Description***
Pole pairs [2124]	n/a	
Stator resistance [2121]	0.02	
Rotor resistance (ACIM) [2453]	0.03	
Rotor leakage inductance (ACIM) [2454]	0.00025	
Nominal magnetizing inductance [2455]	0.003	
Nominal flux (ACIM) [245A]	0.28	
Nominal motor speed (ACIM) [2492]	n/a	
Nominal motor torque (ACIM) [2501]	n/a	
Norm DC link voltage [2164]	n/a	DC link voltage, which is used for the application

Table 45 – ACIM Basic Motor Parameters

If the saturation behavior of the magnetizing inductance is unknown, refer to chapter 10.2.3. Use the default values as 1st approximation:

Nominal magnetizing inductance [2455]: Refer to the motor datasheet

10.2.2 Current Controller

To configure the current controller, a current step has to be generated with the I_d part of the current. In difference to the IPM motor these steps cannot be carried out using the Automatic Test Mode of Q-Control, because the magnetizing current I_d is calculated by the ACIM controller.

The gains K_p and T_n parameters of the controllers are adjusted until the step response has a fast rise without overshoot.

Non linear gains can also be deactivated if not needed. Please refer to chapter 10.1.2.

10.2.2.1 Procedure for Current Controller

Follow the same procedure as for the IPM motor type as described in chapter 10.1.1. Instead of using the automatic test mode to generate the current step, do it as follows.

1. Set the value for the current step to be done in parameter *Minimal magnetizing current (ACIM) [2458]* (directly apply the full step value).
2. Turn on PWM.
3. Wait 2 seconds (until Scope has triggered).
4. Turn off PWM.

First do the tuning of the Id current controller. When finished copy the values of all the parameters found for Id to the respective Iq parameters.

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10.2.3 Iron Saturation

The saturation behavior of the magnetizing inductance depends on the current, which flows through it.

Reminder:

Voltage equation: $u_{sq} - i_d \cdot R_s = L_m \cdot \omega_{elec} \cdot i_d$

Magnetizing inductance: $L_m = \frac{u_q - i_d \cdot R_s}{\omega_{mec} \cdot p \cdot i_d}$

10.2.3.1 Setup and Preconditions

- Constant speed at 50% of the rated speed.
- Reference torque = 0.

10.2.3.2 Parameters

Parameter	*Typical value*	*Description*
Configuration vector control [2150]	0x000007F9	Enable the set torque filter
Minimal magnetizing current (ACIM) [2458]	n/a	Make several measurements with the current step values proposed in the excel sheet
Nominal magnetizing inductance [2455]	n/a	Nominal magnetizing inductance before saturation. Calculated by excel sheet.
Magnetizing inductance coefficient 0 [2457-1]	n/a	Polynomial coefficient 0 (C_0). Calculated by excel.
Magnetizing inductance coefficient 1 [2457-2]	n/a	Polynomial coefficient 1(C_1 * $_{Id}$). Calculated by excel.
Magnetizing inductance coefficient 2 [2457-3]	n/a	Polynomial coefficient 1(C_2 * isd^2). Calculated by excel.

Table 46 – ACIM Iron Saturation Parameters

10.2.3.3 Procedure

The goal is to take several measurement points to obtain a good representation of the saturation characteristics. For this test, the user can increase the $_{Id}$ current up to the nominal current of the motor. Before doing this test, the following parameters must be changed:

To measure the saturation, follow these steps:

1. Use the parameter *Minimal magnetizing current (ACIM) [2458]* to define a current "I_d" reference. Start with about 5% of nominal phase current.
2. Take note of the voltage "U_q" and "U_d" as well as "I_d". Fill in the values for each measurement in the respective field in the worksheet ACIM Lm in the Setup Calculations Excel file (see [3])

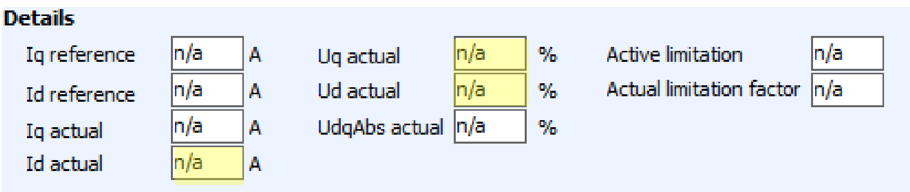


Figure 45 – Measurement of the iron saturation with Q-Control

3. Repeat step 1 and 2 with a current step I_d value increased by 5% to 10%.

Proposed values for current steps are available in the excel sheet, if maximum current of motor has been defined before.

After completing the measurement, follow the steps indicated in the worksheet.

Measurement				
Ud %	Uq %	Id A	Ud V	Uq V
5	9	10	11.54701	20.78461
5.5	16.7	20	12.70171	38.56700
7.7	28	40	17.78239	64.66323
8.5	36.5	60	19.62991	84.29314
9.2	43.8	80	21.24649	101.15177
10	50	100	23.09401	115.47005
10.5	53	120	24.24871	122.39826
11.5	58	140	26.55811	133.94526
10.8	61	160	24.94153	140.87347
10.5	61	180	24.24871	140.87347
10.5	65	200	24.24871	150.11107

Figure 46 – Example: Measurement of saturation

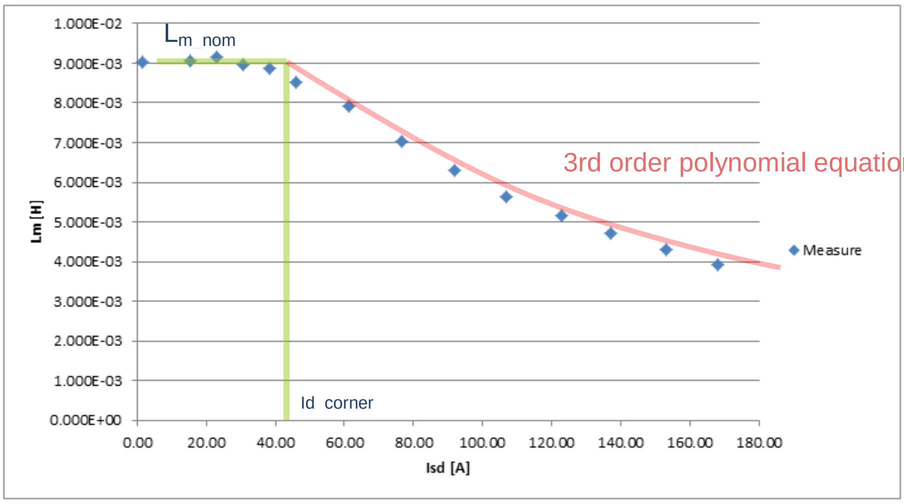


Figure 47 – Magnetizing inductance

This curve can be split into two ranges:

- **Section without saturation:** The inductance is constant until the corner “I_{d_corner}”.
- **Section with saturation:** A 3rd order polynomial equation can be found to approximate the behavior in this area.

10.2.4 Torque or Efficiency Optimization

There are three different methods available to control the flux in the motor (without taking the field weakening area into account):

- Constant flux
- Flux optimized for torque dynamic
- Flux optimized for efficiency

10.2.4.1 Setup and Preconditions

- Previous step of ACIM setup completed

10.2.4.2 Parameters

Parameter	*Typical value*	*Description*
Magnetizing current constant [2459-1]	n/a	Start value = 0. Values calculated by tool
Magnetizing current coefficient 0 [2459-2]	n/a	Start value = 0. Values calculated by tool
Magnetizing current coefficient 1 [2459-3]	n/a	Start value = 0. Values calculated by tool
Magnetizing current coefficient 2 [2459-4]	n/a	Start value = 0. Values calculated by tool
Constant for Iq to flux [2500]	n/a	
Coefficient 0 for Iq to flux [2490-1]	n/a	
Coefficient 1 for Iq to flux [2490-2]	n/a	
Coefficient 2 for Iq to flux [2490-3]	n/a	

Table 47 – ACIM Optimization Parameters

10.2.4.3 Procedure

1) Constant flux: The nominal magnetizing current (peak) should be written into the parameter “Magnetizing current constant” and the nominal flux value from the datasheet should be written into the parameter *Constant for Iq to flux [2500].* If this information is not available in the datasheet, the flux can be calculated with the following equation:
   $\lambda = Lm_{nom} \cdot i_{mag} \cdot \sqrt{2}$
2) Flux optimized for torque dynamic (contact local sales for more information)
3) Flux optimized for efficiency (contact local sales for more information)

10.2.5 Reference Torque Adjustment (measured)

Without this calibration, the effective torque produced will not be the same as the reference torque. This is because the torque of an ACIM motor is not proportional to the I_q current. This chapter defines how to proceed to make this adjustment, using a test bench with a torquemeter.

10.2.5.1 Setup and Preconditions

- Previous step of ACIM setup completed.
- Motor is driven by test bench in speed control mode at 500 rpm.
- Apply a “set torque” of 20% with Q-Control.

10.2.5.2 Parameters

Parameter	*Typical value*	*Description*
Adapt torque (ACIM) [2499]	1	

Table 48 – ACIM Reference Torque Filter Parameters

10.2.5.3 Procedure

1. Modify the parameter *Adapt torque (ACIM) [2499]* until test bench’s torquemeter shows the same value as the requested torque

10.2.6 Reference Torque Filter

To minimize the influence of any noise on the torque reference, a torque filter can be applied. The time constant for this filter can be changed by the user:

Parameter	***Typical value***	***Description***
Reference torque filter [2128]	1e-6	Time constant for the torque filter

Table 49 – ACIM Reference Torque Filter Parameters

10.2.7 Slip Limit Definition

To avoid that slip is greater than the pull-out slip, a slip limiter is implemented. In normal operation, the pull-out slip should not be reached, but in the field weakening area, this pull-out slip could easily be reached if operating at high speeds.

Parameter	***Typical value***	***Description***
Maximum slip (ACIM) [248F]	4	Limit where the torque is set at 0%

Table 50 – ACIM Slip Limit Parameters

10.2.8 Field Weakening ACIM

In field weakening I_d current must be reduced to reduce the induced voltage of the motor to be able to still generate the requested torque.

10.2.8.1 Setup and Preconditions

- The test bench shall drive the motor with a speed just below the field weakening point. ($U_{dq\text{-}abs}$ around 80%).
- Enable PWM.

10.2.8.2 Parameters

Parameter	***Typical value***	***Description***
Configuration vector control [2150]	0x020014F9	Configuration of vector control
Voltage limit 1 [2495]	0.92	First $U_{dq\text{-}abs}$ corner point
Voltage limit 2 [2496]	0.94	Second $U_{dq\text{-}abs}$ corner point
Voltage limit 3 [2497]	0.95	Third $U_{dq\text{-}abs}$ corner point
KFact FW control limit Id 1 [2494]	0.01	Cutback factor above first corner point (Id reduction)
KFact FW control limit Id 2 [2505]	0.5	Cutback factor above second corner point. (Id reduction)
KFact FW control limit 1 [214C]	0.1	Cutback factor above third corner point. (Iq reduction)
Udq absolute vector maximum length [215F]	0.97	Hold PI controller integrator
Norm DC link voltage [2164]		Voltage of normal operation

Table 51 – Field Weakening Parameters

10.2.8.3 Scope Settings

FieldWeakening_ACIM.ssf

10.2.8.4 Procedure

1. Enable PWM.
2. Make a torque step and record it with the scope.
3. Changes of any KFact parameter should not affect the captured signals.
4. Make sure the speed is just at the beginning of the field weakening region and with the torque step the motor is already in the field weakening region. $U_{dqAbsFiltered}$ > Voltage limit 1 [2495].
5. If the field weakening is working, I_d will be reduced, if $U_{dqAbsFiltered}$ is higher than the parameter Voltage limit 1 [2495]. When $U_{dqAbsFiltered}$ goes higher than Voltage limit 3 [2497], also I_q will be reduced.
6. Set KFact as high as possible without inducing oscillations in the measured currents.
7. Repeat steps 3 and 6 at different speed until the FW reacts as fast as possible without oscillations.

Example:

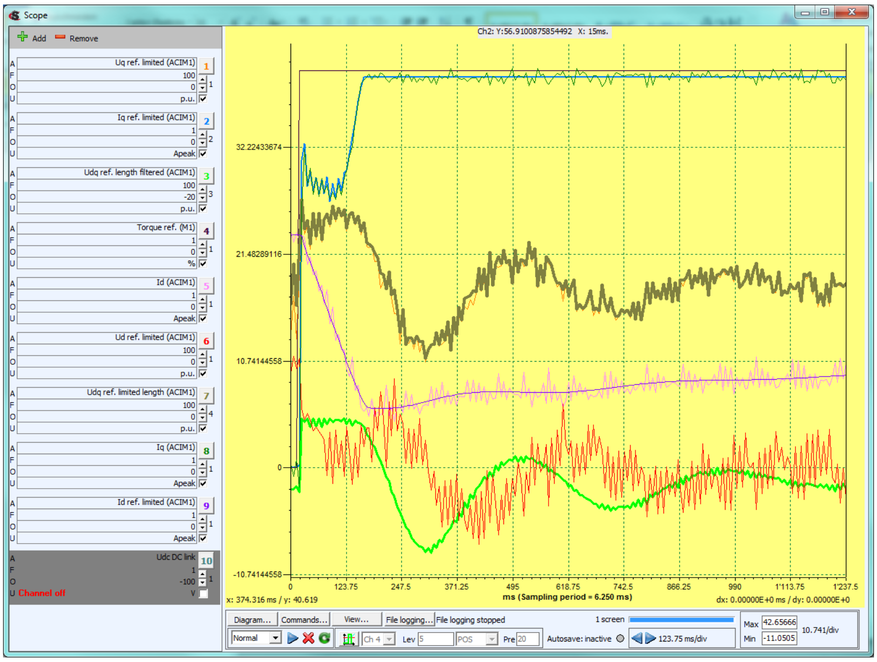


Figure 48 – Field Weakening Tuning

10.2.9 *Torque Calculation Adjustment*

Without this calibration, the torque calculation will not be adjusted and depending on the machine, the torque calculation could have a constant error. This chapter defines how to proceed to make this adjustment, using a test bench with torque meter.

Make sure that the steps defined in chapter 10.2.5 are carried out before doing the steps in this chapter.

10.2.9.1 Setup and Preconditions

- Previous step of ACIM setup completed.
- Motor is driven by test bench in speed control with 50% of the rated speed.
- Apply a “set torque” of 50% with Q-Control.

10.2.9.2 Parameters

Parameter	*Typical value*	*Description*
Gain for actual torque feedback (ACIM)	1	Gain used to adjust actual torque

[2516]		feedback.
Nominal motor torque (ACIM) [2501]	n/a	Torque from datasheet

Table 52 – ACIM Torque calculation Parameters

10.2.9.3 Procedure

1. Change the parameter *Gain for actual torque feedback (ACIM) [2516]* to obtain the same value than the reference value.

10.2.10 ACIM Tuning Issues

Symptoms	***Possible reasons*** ***1 = most probable*** ***6 = least probable***	***Possible solution***
Oscillation of I_d and I_q currents compared to the reference	Ki parameter of the current regulator	See 10.2.2 page 74 **or** try to decrease this value
Delay of the I_d and I_q currents compared to the reference	K_p or Ki parameter of the current regulator	See 10.2.2 page 74 **or** try to increase the K_p value then the Ki value
Torque too small compared to the reference	"Adapt" value Polynomial equation "*I_q to Flux*" Polynomial equation "*Magnetizing Current*" Magnetizing inductance approximated too small Slip limit too small SKAI Subtype wrong Voltage limit too small	1) Check *Adapt torque (ACIM) [2499]* parameter and try to increase the value 2) See 10.2.5.3 page 77 **or** if the "**torque**" or "**efficiency**" optimization is selected. 3) See chapter 10.2.4 and check if the "**torque**" or "**efficiency**" optimization is selected. Verify the polynomial coefficients. 4) See 10.2.3 page 75 5) See 10.2.7 page 78 **or** increase the limit 6) Verify that the SKAI type and subtype are set correctly. 7) Check *Field weakening* parameters (see chapter 0)
Torque too high compared to the reference	"Adapt" value Polynomial equation "*I_q to Flux*" Polynomial equation *"Magnetizing Current*" Magnetizing inductance approximated too small	1) Check *Adapt torque (ACIM) [2499]* parameter and try to increase the value. 2) See 10.2.5.3 page 77 3) **or** if the "*torque*" or "*efficiency*" optimization is selected, please call Drivetek to be sure that the polynomial equation is right. 4) See chapter 10.2.4 and check if the "*torque*" or "*efficiency*" optimization is selected.
Torque oscillation before the field weakening area	PI regulator Filter for the current measurement not enable Voltage limit too big	1) See 10.2.2 page 74 2) In the parameter list, Vector control, Configuration, control that the value 0x000007F9 is right 3) Check *Field weakening* parameters (see chapter 0)
Torque oscillation in the field weakening area	"*K_p for field weakening*" too big Voltage limit too big	1) See 0 page 78 **or** decrease the value 2) Check *Field weakening* parameters (see chapter 0).

Table 53 – ACIM Setting Issues

10.3 Common Settings

In this chapter parameters of features available for all motor types are tuned.

10.3.1 Dead Time Compensation

10.3.1.1 Setup and Preconditions

- The current control is well adjusted.
- Apply nominal DC link voltage.
- Motor is driven by test bench at NO load with 1-5% of maximum motor speed.
- PWM are enabled.
- Activate the Dead Time Compensation in the parameter *Configuration vector control [2150]*. The typical value is 0x000007F9).
- Test in both directions.
- Cooling system must be on.

10.3.1.2 Criteria

The phase currents do not show a dead time anymore.

10.3.1.3 Parameters

Parameter	***Typical value***	***Description***
Configuration vector control [2150]	0x000007F9	Enable Dead Time Compensation
Dead time compensation [2147]		
Dead time minimal current [2148]	0.01	
Dead time slope [2149]	0.001	

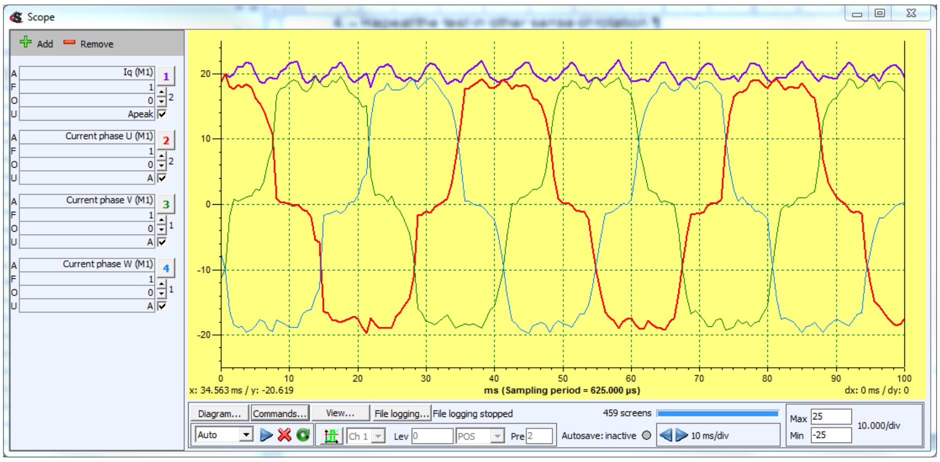
Table 54 - Dead Time Compensation Parameters

10.3.1.4 Scope settings

- DeadTimeCompensation.ssf

10.3.1.5 Procedure

1. Open the motor test function “Current regulator” in Q-Control and apply current at 0° (pure I_q). Start with small values and increase to higher currents.
2. Verify the phase currents in the Scope window.
3. Adjust the parameter *Dead time compensation [2147]* until the phase current has an acceptable sinusoidal shape (see Figure 15).
4. Repeat the test in other sense of rotation.



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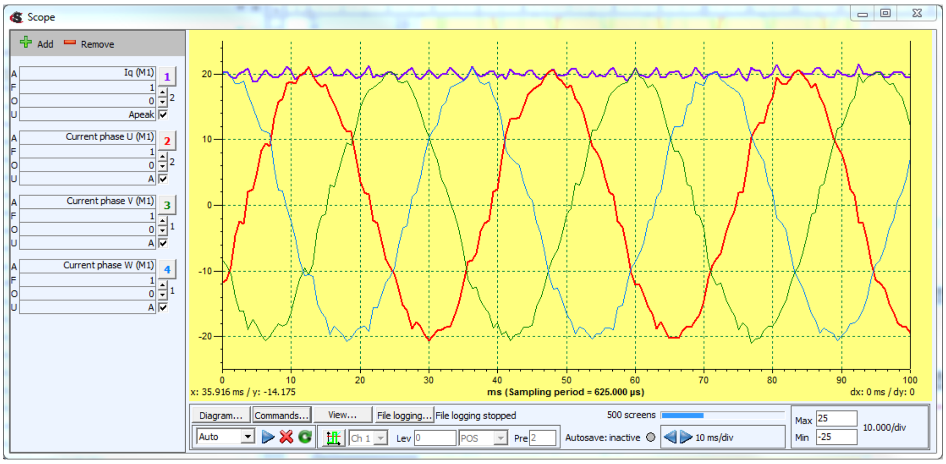

11 Trouble Shooting

11.1 Hardware Trips

Usually hardware trips should never occur in normal operation. If a hardware trip level has been reached, the cutback limiter configuration must be verified.

Error code	***Description***	***Possible solution***
0x01	DESAT	Check motor cabling for short-circuits (phase-phase or phase-shield). Check parameters for current controllers (e.g. "gain K"). (see 10.1.2 for IPM or 10.2.2 ACIM)
0x02	5V supply too low	Check for short circuits in encoder supply wiring. Verify that encoder current consumption does not exceed the specification of SKAI inverter.
0x04	*OT over* temperature (PCB or DCB)	Check for sufficient cooling of the SKAI power module.
0x08	Auxiliary supply low	Check the auxiliary power supply.
0x10	Over current I1, I2 or I3	Check motor cabling for short circuits (phase-phase or phase-shield). Check parameters for current controllers (e.g. "gain K"). Check the maximum current parameters (*Maximum current motor [2100]* and *Maximum absolute value of current (FW) [2142]*)
0x80	DC link voltage high	Check the battery voltage and the parameters for the DC-Link voltage (**DC link** parameters).

Table 55 – Hardware Trips

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11.2 System Error 1 (Software Trips)

Error code	*Description*	*Possible solution*
0x01	PCB over temperature	Check the parameters for the electronic temperatures (i.e. *Maximum DCB temperature [210C]* and *Maximum PCB temperature [2108]).* Check for sufficient cooling of the SKAI power module.
0x02	DC link under voltage or over voltage detected	Check the parameters for the DC-Link voltage (*DC link* parameters).
0x04	Motor over temperature	Check the parameters for the motor temperatures (max. temperatures, sensor type: *Maximum motor temperature [210A]*). Check for sufficient cooling of the SKAI power module.
0x08	Over current	Check motor cabling for short circuits (phase-phase or phase-shield). Check parameters for current controllers (e.g. "gain K") (see 10.1.2 for IPM or 10.2.2 ACIM). Check the maximum current parameters (*Maximum current motor [2100]* and *Maximum absolute value of current (FW)* [2142]*)*
0x10	Watchdog	Should never happen. A fatal error occurred in the firmware. Please contact support.
0x20	Over speed	Check the parameter max speed (see *Maximum speed [2102]*). Verify that encoder signals are noise-free.
0x40	Application error	Customer specific error.
0x80	Communication error	Check correct implementation of "Life Guarding" on the CAN bus master. Check CAN bus wiring.

Table 56 – Software trips: System error 1

11.3 System Error 2 (Software Trips)

Error code	*Description*	*Possible solution*
0x01	reserved	
0x02	reserved	
0x04	Motor temperature sensor fault	Check the parameter for motor temperature sensor. (see Motor temperature sensor type [214A]). Check the wiring of temperature sensors.
0x08	Error in vector control loop (e.g. IqRef, IqAct difference)	Check the parameter of maximum difference between reference current and actual current (see Maximum current difference [2146]). Make sure that the motor is properly connected to the SKAI inverter.
0x10	Referencing motor failed	Verify your position sensor.
0x20	Digital error input is in the error state	An error was indicated to QUASAR over a digital input. Check parameter *Configuration hardware [2140]*.You may disable the feature if the digital input is not used for error indication.
0x40	Encoder error	Check encoder wiring. In case of an incremental encoder make sure that the index line is present.
0x80	reserved	

Table 57 – Software trips: System error 2

11.4 System Warning

Error code	*Description*	*Possible solution*
0x01	Electronic over temperature warning	Check the parameters for the electronic temperatures (i.e. *Warning DCB temperature [210B]* and *Warning PCB temperature [2107]*).
0x02	Cutback limiter active	A cutback limiter is active.
0x04	Reference or limits in RxPDO's were adjusted to valid values	Check the reference values sent over RxPDO's. Some value does violate validation rules.
0x08	DC link capacitance discharge failure	Feature not yet available
0x10	Cutback limiter active	A minimum or maximum cutback limiter is active and reduces the requested torque. Check the limitation flags to verify which limiter is active (CANopen object 0x20a8)
0x20	Boot-up sequence not finished	Initialization failed. Should never happen, contact sales.
0x40	One or more initialization(s) failed	Initialization failed. Should never happen, contact sales
0x80	One or more device communication failed	Initialization failed. Should never happen, contact sales

Table 58 – System warnings

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13 Appendix B – Parameter Description

Parameters for QUASAR (Version V1.03.0)

13.1 Inverter

SKAI inverter specific parameters.

13.1.1 Type and version

Contains parameters for type and version of the SKAI inverter

Inverter Type [21A0]

Name	**Inverter Type [21A0]**
Description	Defines the type of SKAI. Important: The SKAI does not provide automatic hardware detection therefore this parameter must be programmed manually. 0: SKAI not yet defined (no operation possible) 1: Low voltage single SKAI 2: Low voltage dual SKAI 3: High voltage single SKAI (Engineering sample) 4: High voltage single SKAI (Serie) Applied at start-up (reset needed)
Unit	-
Index	0x21a0
Subindex	0
Type	DT_U16
Default value	4
Range	0 ... 4

Inverter Subtype [21A1]

Name	**Inverter Subtype [21A1]**
Description	Defines the subtype. The subtype is given by the voltage class designation. Important: The SKAI does not provide automatic hardware detection, therefore this parameter must be programmed manually 0: not defined (no operation possible) 1: 100V 2: 150V 3: 200V 4: 600V 5: 1200V Applied at start-up (reset needed)
Unit	-
Index	0x21a1
Subindex	0
Type	DT_U16
Default value	4
Range	0 ... 5

Inverter Release [21A2]

Name	**Inverter Release [21A2]**
Description	Gives information about the hardware version of the SKAI. Currently not supported by SKAI hardware.
Unit	-
Index	0x21a2
Subindex	0
Type	DT_U32
Default value	
Range	...

13.1.2 Hardware

Contains hardware related parameters for the inverter.

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Configuration hardware [2140]

Name	**Configuration hardware [2140]**
Description	Defines several hardware related options 0000 0001: MP_DO_C1 for angle output 0000 0002: MP_DO_C1 for general purpose output controlled over CAN 0000 0004: MP_DO_C1 for ABZap Encoder supply or Encoder update 0000 0008: MP_DO_C1 for error signal 0000 0010: MP_DO_C2 for Angle output 0000 0020: MP_DO_C2 for general purpose output controlled over CAN 0000 0040: MP_DO_C2 for ABZap Encoder supply or Encoder update 0000 0080: MP_DO_C2 for error signal 0000 0100: motor direction inverted 0000 0200: change phase sequence v = w, w = v 0000 0400: change counting sequence from encoder 0000 0800: If set QEP counter is reset on detection of every index. If not set QEP counter is always reset at first index after startup or when within drift line ignore and error limit (see drift line error) 0000 1000: only one calculation per PWM 0000 2000: reserved 0000 4000: reserved 0000 8000: reserved 0001 0000: Invert PWM outputs 0002 0000: PLL is used for encoder 0004 0000: reserved 0008 0000: If set PS_AI_C1 resp. PS_AI_C2 inputs are used for Sin/Cos Encoder otherwise MP_AI_C1 resp. MP_AI_C2 are used 0010 0000: reserved Applied at start-up (reset needed)
Unit	-
Index	0x2140
Subindex	0
Type	DT_U32
Default value	8
Range	0 ... 4294967295

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Digital input generates an error [214E]

Name	**Digital input generates an error [214E]**
Description	Defines which signal level at the MP_DI_C1 input generates an error. 0: MP_DI_C1 input error disabled 1: High at MP_DI_C1 input generates an error 2: Low at MP_DI_C1 input generates an error Applied immediately
Unit	-
Index	0x214E
Subindex	0
Type	DT_I16
Default value	0
Range	0 ... 65535

PWM frequency [214F]

Name	**PWM frequency [214F]**
Description	Defines the frequency of the motor output PWMs and the motor control calculation frequency. Motor control runs with twice the PWM frequency (for dual inverters with limitations apply for PWM frequencies higher than 8kHz). Increasing the frequency raises the switching losses. Applied at start-up (reset needed)
Unit	Hz
Index	0x214F
Subindex	0
Type	DT_U16
Default value	8000
Range	4000 ... 16000

PWM mode [215B]

Name	PWM mode [215B]
Description	Defines the PWM mode used. 0: SVM 1: DPWMA 2: DPWMB Applied immediately
Unit	-
Index	0x215B
Subindex	0
Type	DT_U8
Default value	0
Range	0 ... 2

Current gain phase 1 [212A]

Name	Current gain phase 1 [212A]
Description	Defines the correction factor for the current measurement gain of phase U. Applied immediately
Unit	p.u.
Index	0x212A
Subindex	0
Type	DT_F32
Default value	1
Range	0.98 ... 1.02

Current gain phase 3 [212B]

Name	Current gain phase 3 [212B]
Description	Defines the correction factor for the current measurement gain of phase W. Applied immediately
Unit	p.u.
Index	0x212B
Subindex	0
Type	DT_F32
Default value	1
Range	0.98 ... 1.02

Filter constant for analog input C1 [2151]

Name	**Filter constant for analog input C1 [2151]**
Description	Defines the filter constant for analog input MP_AI_C1 Applied at start-up (reset needed)
Unit	s
Index	0x2151
Subindex	0
Type	DT_F32
Default value	0
Range	...

Filter constant for analog input C2 [2152]

Name	**Filter constant for analog input C2 [2152]**
Description	Defines the filter constant for analog input MP_AI_C2 Applied at start-up (reset needed)
Unit	s
Index	0x2152
Subindex	0
Type	DT_F32
Default value	0
Range	...

Filter constant for analog input C3 [2153]

Name	**Filter constant for analog input C3 [2153]**
Description	Defines the filter constant for analog input MP_AI_C3 Applied at start-up (reset needed)
Unit	s
Index	0x2153
Subindex	0
Type	DT_F32
Default value	0
Range	...

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Warning PCB temperature [2107]

Name	**Warning PCB temperature [2107]**
Description	Defines the warning level of the maximum cutback limiter of PCB temperature. If the PCB temperature is greater than this value, the cutback limiter starts limiting torque and a warning is generated. The cutback limiter has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	°C
Index	0x2107
Subindex	0
Type	DT_F32
Default value	75
Range	0 ... 114

Maximum PCB temperature [2108]

Name	**Maximum PCB temperature [2108]**
Description	Defines the error level of the maximum cutback limiter of PCB temperature. If the PCB temperature is greater than this value, PWM is turned off and an error is generated. The cutback limiter has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	°C
Index	0x2108
Subindex	0
Type	DT_F32
Default value	85
Range	0 ... 115

Warning DCB temperature [210B]

Name	**Warning DCB temperature [210B]**
Description	Defines the warning level of the maximum cutback limiter of DCB temperatures. If any DCB temperature is greater than this value, the cutback limiter starts limiting torque and a warning is generated. The cutback limiter has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	°C
Index	0x210B
Subindex	0
Type	DT_F32
Default value	114
Range	0 ... 114

Maximum DCB temperature [210C]

Name	**Maximum DCB temperature [210C]**
Description	Defines the error level of the maximum cutback limiter of DCB temperatures. If any DCB temperature is greater than this value, PWM is turned off and an error is generated. The cutback limiter has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	°C
Index	0x210C
Subindex	0
Type	DT_F32
Default value	115
Range	0 ... 115

13.1.3 Information

Contains parameters with information about operation times

PWM ON time information [2201]

Name	**PWM ON time information [2201]**
Description	Gives the time in seconds since the inverter was switched on (PWM enabled).
Unit	s
Index	0x2201
Subindex	0
Type	DT_U32
Default value	27651
Range	...

Motor rotating time information [2202]

Name	**Motor rotating time information [2202]**
Description	Gives the time since the motor started (motor speed > 0) is saved in the motor rotating time.
Unit	s
Index	0x2202
Subindex	0
Type	DT_U32
Default value	31
Range	...

System up time information [2203]

Name	**System up time information [2203]**
Description	This parameter gives the time since last power on or reset of the system.
Unit	s
Index	0x2203
Subindex	0
Type	DT_U32
Default value	30
Range	...

13.2 DC link

Contains parameters related with the DC link

Warning minimal DC link voltage [2117]

Name	**Warning minimal DC link voltage [2117]**
Description	Defines the warning level of the minimum cutback limiter of DC link voltage. If the DC link voltage is less than this value, the cutback limiter starts limiting torque and a warning is generated. The cutback limiter is only active in motoring mode and has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	V
Index	0x2117
Subindex	0
Type	DT_F32
Default value	55
Range	...

Minimal DC link voltage [2105]

Name	**Minimal DC link voltage [2105]**
Description	Defines the error level of the minimum cutback limiter of DC link voltage. If the DC link voltage is less than this value, PWM is turned off and a DC link under or over voltage error is generated. The cutback limiter is only active in motoring mode and has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	V
Index	0x2105
Subindex	0
Type	DT_F32
Default value	50
Range	...

Warning maximum DC link generator voltage [2118]

Name	**Warning maximum DC link generator voltage [2118]**
Description	Defines the warning level of the maximum cutback limiter of DC link voltage. If DC link voltage is above this value the cutback limiter starts limiting torque and a warning is generated. The cutback limiter is only active in generating mode and has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	V
Index	0x2118
Subindex	0
Type	DT_F32
Default value	83
Range	...

Maximum DC link voltage generator mode [210F]

Name	**Maximum DC link voltage generator mode [210F]**
Description	Defines the error level of the maximum cutback limiter of DC link voltage. If the DC link voltage is greater than this value, PWM is turned off and a DC link under or over voltage error is generated. The cutback limiter is only active in generating mode and has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	V
Index	0x210F
Subindex	0
Type	DT_F32
Default value	72
Range	...

Maximum DC link voltage [2106]

Name	**Maximum DC link voltage [2106]**
Description	If the DC link voltage is greater than this value, DC link over voltage detected error will be generated. Applied immediately
Unit	V
Index	0x2106
Subindex	0
Type	DT_F32
Default value	72
Range	...

Gain for DC link voltage [215E]

Name	**Gain for DC link voltage [215E]**
Description	Defines the gain correction factor for the DC link voltage measurement. If the DC link voltage on the Q-Control display is different than the actual value, this parameter can be used to adjust this. Note: if the indicated voltage is not correct, also check the inverter type and subtype settings. Applied at start-up (reset needed)
Unit	p.u.
Index	0x215E
Subindex	0
Type	DT_F32
Default value	1
Range	...

Maximum power [2145]

Name	**Maximum power [2145]**
Description	Defines the maximum power of the motor. If power is greater than this value, the system will reduce torque to limit the power. Note: power is estimated out of actual set torque (theoretical value) and motor speed. The limiter has to be enabled in parameter 'Configuration vector control [2150]'. Applied immediately
Unit	kW
Index	0x2145
Subindex	0
Type	DT_F32
Default value	120
Range	...

13.2.1 Overvoltage protection

Contains parameters for the overvoltage protection of the DC link (feature only available for specific LV SKAI versions. Contact sales for more information).

Configuration overvoltage protection [217A]

Name	**Configuration overvoltage protection [217A]**
Description	Defines option for the DC link overvoltage protection. 0000 0001 : BOT's are switched on at overvoltage Applied at start-up (reset needed)
Unit	-
Index	0x217a
Subindex	0
Type	DT_U32
Default value	0
Range	0 ... 1

Overvoltage protection OFF minimal DC link voltage [217B]

Name	**Overvoltage protection OFF minimal DC link voltage [217B]**
Description	Minimum DC link voltage, below this level, BOT's are switched off (feature not available for all SKAI types) Applied immediately
Unit	V
Index	0x217b
Subindex	0
Type	DT_F32
Default value	80
Range	...

Overvoltage protection ON max DC link voltage [217C]

Name	**Overvoltage protection ON max DC link voltage [217C]**
Description	Maximum DC link voltage, above this level, BOT's are switched on (feature not available of all SKAI types) Applied immediately
Unit	V
Index	0x217c
Subindex	0
Type	DT_F32
Default value	120
Range	...

13.3 Motor

Contains parameters characterizing the motor

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Motor type [2119]

Name	Motor type [2119]
Description	Defines the motor type: 1: PSM 2: IPM 3: Reserved 4: BLDC 5: ASM (vector control) 6: reserved Applied at start-up (reset needed)
Unit	-
Index	0x2119
Subindex	0
Type	DT_U16
Default value	0
Range	0 ... 6

Pole pairs [2124]

Name	Pole pairs [2124]
Description	Defines the number of pole pairs of the motor. Applied at start-up (reset needed)
Unit	-
Index	0x2124
Subindex	0
Type	DT_F32
Default value	8
Range	1 ...

Stator resistance [2121]

Name	**Stator resistance [2121]**
Description	Defines the stator winding resistance including the connection cables. Applied at start-up (reset needed)
Unit	Ohm
Index	0x2121
Subindex	0
Type	DT_F32
Default value	0.1188
Range	...

Warning speed [2104]

Name	**Warning speed [2104]**
Description	Defines the warning level of the maximum cutback limiter of motor speed. If speed is above this value the cutback limiter starts limiting torque and an over speed warning is generated. The cutback limiter has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	rpm
Index	0x2104
Subindex	0
Type	DT_F32
Default value	6400
Range	0 ... 32768

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Maximum speed [2102]

Name	**Maximum speed [2102]**
Description	Defines the error level of the maximum cutback limiter of speed. If the speed is greater than this value, PWM is turned off and an over speed error is generated. The cutback limiter has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	rpm
Index	0x2102
Subindex	0
Type	DT_F32
Default value	6500
Range	0 ... 32768

Maximum current motor [2100]

Name	**Maximum current motor [2100]**
Description	Defines the maximum q-axis current value set to reach 100 % torque (Scaling only valid for PSM/IPM motors. For ACIM adapt torque parameter is used for scaling). Applied at start-up (reset needed)
Unit	Arms
Index	0x2100
Subindex	0
Type	DT_F32
Default value	300
Range	...

Motor temperature sensor type [214A]

Name	**Motor temperature sensor type [214A]**
Description	Defines the motor temperature sensor (thermistor) type 1: Motor Temperature Sensor disabled 2: Motor Temperature Sensor KTY16 3: Motor Temperature Sensor KTY81-1 4: Motor Temperature Sensor KTY81-2 5: Motor Temperature Sensor KTY82-1 6: Motor Temperature Sensor KTY82-2 7: Motor Temperature Sensor KTY83 8: Motor Temperature Sensor KTY84 9: Motor Temperature Sensor KTY85 10: Motor Temperature Sensor YBB145 11: Motor Temperature Sensor PT100 12: Motor Temperature Sensor NTC10K 13: Motor Temperature Sensor NTC33K 14: Motor Temperature Sensor PT100 15: Motor Temperature Sensor PT1000 Note: Depending onf the inverter type, only a subset of the availble temperature sensors are supported (for more informaton see the QUASAR manaual). Applied at start-up (reset needed)
Unit	-
Index	0x214A
Subindex	0
Type	DT_I16
Default value	7
Range	0 ... 15

Warning motor temperature [2109]

Name	**Warning motor temperature [2109]**
Description	Defines the warning level of the maximum cutback limiter of motor temperature. If motor temperature is above this value the cutback limiter starts limiting torque and a motor overtemperature warning is generated. The cutback limiter has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	°C
Index	0x2109
Subindex	0
Type	DT_F32
Default value	130
Range	0 ... 300

Maximum motor temperature [210A]

Name	**Maximum motor temperature [210A]**
Description	Defines the error level of the maximum cutback limiter of motor temperature. If the motor temperature is greater than this value, PWM is turned off and a motor overtemperature error is generated. The cutback limiter has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	°C
Index	0x210A
Subindex	0
Type	DT_F32
Default value	150
Range	0 ... 320

Motor temperature ADC offset [215D]

Name	**Motor temperature ADC offset [215D]**
Description	Defines the offset added to the measured motor temperature. Use this offset, if the value indicated does not correspond with the actual motor temperature value. Applied immediately
Unit	AD digits
Index	0x215D
Subindex	0
Type	DT_F32
Default value	0
Range	...

13.4 IPM/PSM

Contains parameters for PSM and IPM motors

Parameters of this section are only used if IPM or PSM motor type is defined.

Torque constant [2103]

Name	**Torque constant [2103]**
Description	Defines the motor constant which defines how much torque is generated relative to the current. Applied at start-up (reset needed)
Unit	Nm/Arms
Index	0x2103
Subindex	0
Type	DT_F32
Default value	0.22285715
Range	...

Generator constant [2120]

Name	**Generator constant [2120]**
Description	Defines the generator constant of motor which defines how much voltage is induced relative to speed Applied at start-up (reset needed)
Unit	Vpeak/rad/s
Index	0x2120
Subindex	0
Type	DT_F32
Default value	0.92000002
Range	...

Ld [2165]

Name	**Ld [2165]**
Description	Defines the D-Axis stator self-inductance. Applied immediately
Unit	mH
Index	0x2165
Subindex	0
Type	DT_F32
Default value	0.025
Range	...

Lq [2166]

Name	**Lq [2166]**
Description	Defines the Q-Axis stator self-inductance. Applied immediately
Unit	mH
Index	0x2166
Subindex	0
Type	DT_F32
Default value	0.025
Range	...

13.5 ACIM

Contains parameters for the AC induction motor characteristics. Parameters of this section are only used if ACIM motor type is defined.

Nominal motor speed (ACIM) [2492]

Name	**Nominal motor speed (ACIM) [2492]**
Description	Defines the nominal motor speed Applied when PWM enabled
Unit	rpm
Index	0x2492
Subindex	0
Type	DT_F32
Default value	2000
Range	...

Nominal motor torque (ACIM) [2501]

Name	**Nominal motor torque (ACIM) [2501]**
Description	Defines the nominal motor torque Applied when PWM enabled
Unit	Nm
Index	0x2501
Subindex	0
Type	DT_F32
Default value	240
Range	...

Nominal rotor current (ACIM) [2517]

Name	**Nominal rotor current (ACIM) [2517]**
Description	Defines the nominal rotor current. Applied immediately
Unit	Apeak
Index	0x2517
Subindex	0
Type	DT_F32
Default value	100
Range	...

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Rotor resistance (ACIM) [2453]

Name	**Rotor resistance (ACIM) [2453]**
Description	Defines the rotor resistance. Applied when PWM enabled
Unit	Ohm
Index	0x2453
Subindex	0
Type	DT_F32
Default value	0.028
Range	...

Maximum slip (ACIM) [248F]

Name	**Maximum slip (ACIM) [248F]**
Description	Defines the maximum Slip allowed. Applied when PWM enabled
Unit	%
Index	0x248F
Subindex	0
Type	DT_F32
Default value	2.3
Range	...

*Warning I^2*t rotor protection (ACIM) [2513]*

Name	**Warning I^2*t rotor protection (ACIM) [2513]**
Description	Warning I^2*t limit value. If 'I^2*t limiter' is enabled (refer to parameter 'Configuration vector control [2150]') and cumulated rotor losses (calculated by I^2*t approach) is greater than this value, a linear reduction of the desired torque starts. Applied when PWM enabled
Unit	A^2*s
Index	0x2513
Subindex	0
Type	DT_F32
Default value	900
Range	...

*Maximum I^2*t rotor protection (ACIM) [2514]*

Name	**Maximum I^2*t rotor protection (ACIM) [2514]**
Description	Maximum I^2*t limit value. If 'I^2*t limiter' is enabled (refer to parameter 'Configuration vector control [2150]') and cumulated rotor losses (calculated by I^2*t approach) is greater than this value, the maximum limitation of the requested torque is reached. Applied when PWM enabled
Unit	A^2*s
Index	0x2514
Subindex	0
Type	DT_F32
Default value	1000
Range	...

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Nominal flux (ACIM) [245A]

Name	**Nominal flux (ACIM) [245A]**
Description	Defines the nominal rotor flux. Applied when PWM enabled
Unit	Wb
Index	0x245A
Subindex	0
Type	DT_F32
Default value	0.38699999
Range	...

Stator leakage inductance (ACIM) [2452]

Name	**Stator leakage inductance (ACIM) [2452]**
Description	Defines the stator leakage inductance. Applied when PWM enabled
Unit	mH
Index	0x2452
Subindex	0
Type	DT_F32
Default value	0.23799999
Range	...

Rotor leakage inductance (ACIM) [2454]

Name	**Rotor leakage inductance (ACIM) [2454]**
Description	Defines the rotor leakage inductance. Applied when PWM enabled
Unit	mH
Index	0x2454
Subindex	0
Type	DT_F32
Default value	0.23799999
Range	...

13.6 Magnetizing inductance

Contains parameters defining the magnetizing inductance of AC induction motor

Parameters in this section are only used if ACIM motor type is defined.

Nominal magnetizing inductance [2455]

Name	**Nominal magnetizing inductance [2455]**
Description	Defines the magnetizing inductance. Applied when PWM enabled
Unit	mH
Index	0x2455
Subindex	0
Type	DT_F32
Default value	6.52
Range	...

Magnetizing inductance coefficient 0 [2457-1]

Name	**Magnetizing inductance coefficient 0 [2457-1]**
Description	The coefficient c[0] mapping the magnetizing inductance to a d-axis current. Applied when PWM enabled
Unit	-
Index	0x2457
Subindex	1
Type	DT_F32
Default value	0.0113
Range	...

Magnetizing inductance coefficient 1 [2457-2]

Name	**Magnetizing inductance coefficient 1 [2457-2]**
Description	The coefficient c[1] mapping the magnetizing inductance to a d-axis current. Applied when PWM enabled
Unit	-
Index	0x2457
Subindex	2
Type	DT_F32
Default value	-0.0000661
Range	...

Magnetizing inductance coefficient 2 [2457-3]

Name	**Magnetizing inductance coefficient 2 [2457-3]**
Description	The coefficient c[2] mapping the magnetizing inductance to a d-axis current. Applied when PWM enabled
Unit	-
Index	0x2457
Subindex	3
Type	DT_F32
Default value	0.000000113
Range	...

13.7 Position sensor

Contains parameters to configure the position senor.

Encoder type [2143]

Name	**Encoder type [2143]**
Description	The encoder type is defined with this parameter: 0: Encoder type not yet defined 1: Incremental encoder ABZ 2: Sin/Cos Encoder 3: Encoder with update function 4: Incremental encoder with absolute position (ABZap) 5: Hall Sensor (not valid for ACIM) 6: Resolver Applied at start-up (reset needed)
Unit	-
Index	0x2143
Subindex	0
Type	DT_U16
Default value	1
Range	...

Encoder supply voltage [2176]

Name	**Encoder supply voltage [2176]**
Description	Encoder supply voltage 0: 5V 1: 12V Applied at start-up (reset needed)
Unit	-
Index	0x2176
Subindex	0
Type	DT_U16
Default value	0
Range	...

Encoder angle offset [2123]

Name	**Encoder angle offset [2123]**
Description	Offset between mechanical and electrical system. It is important to tune this parameter when the motor is turning forward. Definition of forward turning: Forward turning means the angle is rising and the speed display in Q-Control shows positive values.
Unit	p.u.
Index	0x2123
Subindex	0
Type	DT_F32
Default value	0.46849999
Range	...

Indexes per mechanical revolution [2136]

Name	**Indexes per mechanical revolution [2136]**
Description	The parameter defines how many numbers of indexes or periods are indicated by the position sensor for one mechanical revolution. If the number of pole pairs is divided by this parameter the result must be a whole number and must be greater than one. If this is not the case the position sensor cannot be used for that motor (no unique or drifting electrical position information) Applied at start-up (reset needed).
Unit	-
Index	0x2136
Subindex	0
Type	DT_F32
Default value	1
Range	...

Encoder delay compensation [2169]

Name	**Encoder delay compensation [2169]**
Description	Correction of signal delay from encoder. Applied immediately
Unit	s
Index	0x2169
Subindex	0
Type	DT_F32
Default value	-0.000006
Range	...

Kp for encoder PLL control [2173]

Name	**Kp for encoder PLL control [2173]**
Description	Kp parameter for PLL on mechanical angle. Applied at start-up (reset needed)
Unit	-
Index	0x2173
Subindex	0
Type	DT_F32
Default value	0.01
Range	0 ... 1

Tn for encoder PLL control [2174]

Name	**Tn for encoder PLL control [2174]**
Description	Tn parameter for PLL on mechanical angle. Applied at start-up (reset needed)
Unit	s
Index	0x2174
Subindex	0
Type	DT_F32
Default value	0.0001
Range	...

Speed filter constant PT2 [213A]

Name	**Speed filter constant PT2 [213A]**
Description	Filter constant for PT2 speed filter. Applied at start-up (reset needed)
Unit	s
Index	0x213A
Subindex	0
Type	DT_F32
Default value	0
Range	...

13.7.1 ABZ/ABZap incremental encoder and resolver

Contains parameters to configure incremental encoders and resolvers. Parameters in this section are only used if either encoder type ABZ, ABZap encoder or resolver is configured.

Configuration incremental encoder [2113]

Name	**Configuration incremental encoder [2113]**
Description	Defines configuration options for the incremental encoder. 0000 0001: Enable encoder drift check Applied at start-up (reset needed)
Unit	-
Index	0x2113
Subindex	0
Type	DT_U32
Default value	1
Range	0 ... 1

Number of encoder lines [2125]

Name	**Number of encoder lines [2125]**
Description	With this parameter the number of encoder lines is specified. Total number of rising and falling signal edges on track A and B Applied at start-up (reset needed)
Unit	-
Index	0x2125
Subindex	0
Type	DT_F32
Default value	4096
Range	6 ...

Encoder lines drift ignore limit [2114]

Name	**Encoder lines drift ignore limit [2114]**
Description	This limit defines how much lines-drift is tolerated and therefore ignored by the software It can be activated by setting the bit in the Safety: Configuration parameter. The lines-drift is calculated between two indexes. Applied immediately
Unit	lines
Index	0x2114
Subindex	0
Type	DT_U32
Default value	5
Range	...

Encoder lines drift error limit [2115]

Name	**Encoder lines drift error limit [2115]**
Description	If an encoder lines drift is enabled, this limit defines how much drift is allowed before an error is set. In between 'ignore limit' and 'error limit' the QEP counter is reset to zero. The drift is calculated in between two index pulses. Note that this option does only make sense, if the encoder counter is not reset on index by default (see Configuration Hardware [2140]). Applied immediately
Unit	lines
Index	0x2115
Subindex	0
Type	DT_U32
Default value	57
Range	...

Encoder lines drift error count [2116]

Name	**Encoder lines drift error count [2116]**
Description	If the encoder has a lines drift, which exceeds the defined lines-drift-error-limit a counter is increased. This parameter defines how many occurences are allowed until an error is generated. The error counter is decremented by one, when a line drift of less than the error limit was detected. E.g. If the parameter is set to 3, the encoder error will be set only, if the defined encoder line drift exceeds the defined error limit four times. Applied immediately
Unit	-
Index	0x2116
Subindex	0
Type	DT_U16
Default value	1
Range	...

13.8 Resolver

Contains parameters for the resolver inverface of HV SKAI. Parameters in this section are only used if encoder type Resolver is configured. This feature is only available for HV SKAIs with resolver interface.

Configuration resolver [2144]

Name	**Configuration resolver [2144]**
Description	Resolver Configuration register 3A, see Semikron technical explanation Applied at start-up (reset needed)
Unit	-
Index	0x2144
Subindex	0
Type	DT_U16
Default value	0
Range	...

Resolver transformation ratio [2175]

Name	**Resolver transformation ratio [2175]**
Description	Resolver transformation ratio 0: 0.23 1: 0.286 Applied at start-up (reset needed)
Unit	p.u
Index	0x2175
Subindex	0
Type	DT_U16
Default value	1
Range	0 ... 1

13.8.1 Sin/Cos encoder

Contains parameters for the SIN/COS encoder signal filtering and processing. Parameters in this section are only used if encoder type Sin/Cos encoder is configured.

Sin/Cos encoder sine gain [2133]

Name	**Sin/Cos encoder sine gain [2133]**
Description	This parameter is used, if a Sine/Cosine-Encoder is used. It allows adjusting the sine-signal of the encoder to the desired amplitude level. Applied at start-up (reset needed)
Unit	-
Index	0x2133
Subindex	0
Type	DT_F32
Default value	0.6501587
Range	...

Sin/Cos encoder sine offset [212D]

Name	**Sin/Cos encoder sine offset [212D]**
Description	This parameter is used, if a sine/cosine encoder is used. It allows adjusting the sine-signal of the encoder to the desired offset level. Applied at start-up (reset needed)
Unit	-
Index	0x212D
Subindex	0
Type	DT_F32
Default value	2.3950195
Range	...

Filter constant for sine input [2184]

Name	**Filter constant for sine input [2184]**
Description	Defines the filter constant for sine input. Applied at start-up (reset needed)
Unit	s
Index	0x2184
Subindex	0
Type	DT_F32
Default value	0
Range	...

Sin/Cos encoder cosine gain [212C]

Name	**Sin/Cos encoder cosine gain [212C]**
Description	This parameter is used, if a Sine/Cosine-Encoder is used. It allows adjusting the cosine-signal of the encoder to the desired amplitude level. Applied at start-up (reset needed)
Unit	-
Index	0x212C
Subindex	0
Type	DT_F32
Default value	0.65693665
Range	...

Sin/Cos encoder cosine offset [212E]

Name	**Sin/Cos encoder cosine offset [212E]**
Description	This parameter is used, if a sine/cosine encoder is used. It allows adjusting the cosine-signal of the encoder to the desired offset level. Applied at start-up (reset needed)
Unit	-
Index	0x212E
Subindex	0
Type	DT_F32
Default value	2.4743652
Range	...

Filter constant for cosine input [2185]

Name	**Filter constant for cosine input [2185]**
Description	Defines the filter time constant for cosine input. Applied at start-up (reset needed)
Unit	s
Index	0x2185
Subindex	0
Type	DT_F32
Default value	0
Range	...

13.8.2 Hall switch angle

Contains parameters to define corrected switching angles for hall sensor operation. The angles can be defined for positive and negative sense of rotation.

The corrected angles defined will only be used in FOC control mode. For BLDC control mode standard hall sensor switching angles apply.

Parameters in this section are only used if encoder type Hall Sensor is configured.

Applied immediately

13.9 Forward

Contains parameters that define switching angles for Hall sensors for positive sense of rotation.

Applied immediately

Hall1 up [21B0-1]

Name	**Hall1 up [21B0-1]**
Description	Angle for low to high transition Applied immediately
Unit	p.u.
Index	0x21b0
Subindex	1
Type	DT_F32
Default value	0
Range	...

Hall1 down [21B0-2]

Name	**Hall1 down [21B0-2]**
Description	Angle for high to low transition Applied immediately
Unit	p.u.
Index	0x21b0
Subindex	2
Type	DT_F32
Default value	1
Range	...

Hall2 up [21B0-3]

Name	**Hall2 up [21B0-3]**
Description	Angle for low to high transition Applied immediately
Unit	p.u.
Index	0x21b0
Subindex	3
Type	DT_F32
Default value	0
Range	...

Hall2 down [21B0-4]

Name	**Hall2 down [21B0-4]**
Description	Angle for high to low transition Applied immediately
Unit	p.u.
Index	0x21b0
Subindex	4
Type	DT_F32
Default value	0
Range	...

Hall3 up [21B0-5]

Name	**Hall3 up [21B0-5]**
Description	Angle for low to high transition Applied immediately
Unit	p.u.
Index	0x21b0
Subindex	5
Type	DT_F32
Default value	0
Range	...

Hall3 down [21B0-6]

Name	**Hall3 down [21B0-6]**
Description	Angle for high to low transition Applied immediately
Unit	p.u.
Index	0x21b0
Subindex	6
Type	DT_F32
Default value	0
Range	...

13.10 Backward

Contains parameters that define switching angles for Hall sensors for negative sense of rotation.

Applied immediately

Hall1 up [21B1-1]

Name	**Hall1 up [21B1-1]**
Description	Angle for low to high transition Applied immediately
Unit	p.u.
Index	0x21b1
Subindex	1
Type	DT_F32
Default value	0
Range	...

Hall1 down [21B1-2]

Name	**Hall1 down [21B1-2]**
Description	Angle for high to low transition Applied immediately
Unit	p.u.
Index	0x21b1
Subindex	2
Type	DT_F32
Default value	0
Range	...

Hall2 up [21B1-3]

Name	**Hall2 up [21B1-3]**
Description	Angle for low to high transition Applied immediately
Unit	p.u.
Index	0x21b1
Subindex	3
Type	DT_F32
Default value	0
Range	...

Hall2 down [21B1-4]

Name	**Hall2 down [21B1-4]**
Description	Angle for high to low transition Applied immediately Applied immediately
Unit	p.u.
Index	0x21b1
Subindex	4
Type	DT_F32
Default value	0
Range	...

Hall3 up [21B1-5]

Name	**Hall3 up [21B1-5]**
Description	Angle for low to high transition Applied immediately
Unit	p.u.
Index	0x21b1
Subindex	5
Type	DT_F32
Default value	0
Range	...

Hall3 down [21B1-6]

Name	**Hall3 down [21B1-6]**
Description	Angle for high to low transition Applied immediately
Unit	p.u.
Index	0x21b1
Subindex	6
Type	DT_F32
Default value	0
Range	...

13.11 Vector control

Contains parameters for vector control settings.

Configuration vector control [2150]

Name	**Configuration vector control [2150]**
Description	This parameter is used to configure the vector control. Each bit is used for another setting, the defined bit definitions are in the following table described. 0000 0001: enable field weak control part (should be enabled) 0000 0002: reserved 0000 0004: enable power limiter. 0000 0008: enable maximum speed cutback limiter 0000 0010: enable maximum motor temperarute cutback limiter 0000 0020: enable maximum electronic temperature (PCB/DCB) cutback limiter 0000 0040: enable Iq-ref/Id-ref filter 0000 0080: enable dead time compensation 0000 0100: enable minimum DC link voltage cutback limiter 0000 0200: enable speed request filter 0000 0400: enable maximum DC link voltage cutback limiter 0000 0800: enable overmodulation 0000 1000: enable NLSF 0000 2000: reserved 0000 4000: reserved 0000 8000: enable S-Shape Torque request filter 0001 0000: reserved 0002 0000: test Id controller 0004 0000: test Iq controller 0008 0000: enable maximum acceleration cutback limiter 0010 0000: Maximum absolute current in function of table 0020 0000: Ld and Lq in function of table 0040 0000: Maximum torque in function of table 0080 0000: enable power limiter 0100 0000: reserved 0200 0000: enable I^2*t limiter. Limit to the maximal I^2*t / rotor losses (for ACIM only)
Unit	-
Index	0x2150
Subindex	0
Type	DT_U32

Default value	0x7F9
Range	0 ... 67108863

Norm DC link voltage [2164]

Name	**Norm DC link voltage [2164]**
Description	Scale base used to normalize DC link voltage. Voltage with which torque Iq/Id tables were measured for IPM. Used for slip limit calculation in ACIM. Applied immediately
Unit	V
Index	0x2164
Subindex	0
Type	DT_F32
Default value	120
Range	...

Calculation factor of time compensation [2127]

Name	**Calculation factor of time compensation [2127]**
Description	This parameter is used to compensate the time it takes to perform the calculations. Applied immediately
Unit	-
Index	0x2127
Subindex	0
Type	DT_F32
Default value	0.00000225
Range	...

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Reference torque filter [2128]

Name	**Reference torque filter [2128]**
Description	This parameter is used to set the S-Shape torque filter time constant. Applied at start-up (reset needed)
Unit	s
Index	0x2128
Subindex	0
Type	DT_F32
Default value	0.02
Range	...

Acceleration calculation filter [215C]

Name	**Acceleration calculation filter [215C]**
Description	The acceleration torque filter time constant. Applied at start-up (reset needed)
Unit	s
Index	0x215C
Subindex	0
Type	DT_F32
Default value	0.01
Range	...

Acceleration limit start [216C]

Name	**Acceleration limit start [216C]**
Description	Defines the start of limitation for maximal motor acceleration. The limiter has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	rad/s^2
Index	0x216C
Subindex	0
Type	DT_F32
Default value	1000
Range	...

Maximum acceleration [216D]

Name	**Maximum acceleration [216D]**
Description	Defines the maximum motor acceleration. The limiter has to be enabled in parameter 'Configuration vector control [2150]'. Applied at start-up (reset needed)
Unit	rad/s^2
Index	0x216D
Subindex	0
Type	DT_F32
Default value	1200
Range	...

Speed limit delta for slope [215A-1]

Name	**Speed limit delta for slope [215A-1]**
Description	Defines the value to calculate slope of the reference speed limit cutback limiter (symetric and asymetric). The slope is calculated by -1/<value>. Applied at start-up (reset needed)
Unit	rpm
Index	0x215A
Subindex	1
Type	DT_F32
Default value	30
Range	...

Maximum speed to switch PWMs on [216A]

Name	**Maximum speed to switch PWMs on [216A]**
Description	Defines the maximum speed at which the PWMs can still be enabled. Applied immediately
Unit	rpm
Index	0x216a
Subindex	0
Type	DT_F32
Default value	500
Range	...

Iq reference filter constant [2154]

Name	**Iq reference filter constant [2154]**
Description	Filter time constant for Iq current reference. Applied at start-up (reset needed)
Unit	s
Index	0x2154
Subindex	0
Type	DT_F32
Default value	0.00625
Range	...

Id reference filter constant [2155]

Name	**Id reference filter constant [2155]**
Description	Filter time constant for Id current reference. Applied at start-up (reset needed)
Unit	s
Index	0x2155
Subindex	0
Type	DT_F32
Default value	0.00625
Range	...

Udqabs filter constant [2183]

Name	**Udqabs filter constant [2183]**
Description	Filter constant for Udqabs filtering. Applied at start-up (reset needed)
Unit	s
Index	0x2183
Subindex	0
Type	DT_F32
Default value	0.003
Range	...

13.11.1 ACIM IFOC

Contains parameter for AC Induction Motor (ACIM) in Indirect Field Oriented Control (IFOC). Parameters in this section are only used if ACIM motor type is defined.

Flux filter for slip limiter [2493]

Name	**Flux filter for slip limiter [2493]**
Description	Time constant for the flux filter.
Unit	s
Index	0x2493
Subindex	0
Type	DT_F32
Default value	0.0008
Range	...

*Ki for I^2*t protection (ACIM) [2518]*

Name	**Ki for I^2*t protection (ACIM) [2518]**
Description	Defines the integration rate of I^2*t protection (used for rotor loss limitation)
Unit	-
Index	0x2518
Subindex	0
Type	DT_F32
Default value	0.00001
Range	...

Udq_abs filter (ACIM) [2498]

Name	**Udq_abs filter (ACIM) [2498]**
Description	Time constant for the udq actual filter.
Unit	s
Index	0x2498
Subindex	0
Type	DT_F32
Default value	0.01
Range	...

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Idq actual filter (ACIM) [2515]

Name	**Idq actual filter (ACIM) [2515]**
Description	Time constant for the Idq actual filter.
Unit	s
Index	0x2515
Subindex	0
Type	DT_F32
Default value	0.0625
Range	...

Adapt torque (ACIM) [2499]

Name	**Adapt torque (ACIM) [2499]**
Description	Defines an factor to scale the requested torque with the effectivly produced torque.To adjust this parameter, command a reference torque of 10%. After that, adjust the coefficient to obtain 10% of the nominal torque (Use a torque meter measuer the produced torque).
Unit	-
Index	0x2499
Subindex	0
Type	DT_F32
Default value	1.488
Range	...

Gain for actual torque feedback (ACIM) [2516]

Name	**Gain for actual torque feedback (ACIM) [2516]**
Description	Gain used to adjust actual torque feedback. Torque is calculated using motor model.
Unit	p.u.
Index	0x2516
Subindex	0
Type	DT_F32
Default value	9494
Range	...

Minimal magnetizing current (ACIM) [2458]

Name	**Minimal magnetizing current (ACIM) [2458]**
Description	The minimum magnetizing current which will be produced. Applied immediately
Unit	Apeak
Index	0x2458
Subindex	0
Type	DT_F32
Default value	0
Range	...

13.11.2 Magnetizing current

Contains parameters for the calculation of isd. Parameters in this section are only used if ACIM motor type is defined.

Magnetizing current constant [2459-1]

Name	**Magnetizing current constant [2459-1]**
Description	Mapping constant. The value to be configured must be requested at local sales. Applied immediately
Unit	-
Index	0x2459
Subindex	1
Type	DT_F32
Default value	0
Range	...

Magnetizing current coefficient 0 [2459-2]

Name	**Magnetizing current coefficient 0 [2459-2]**
Description	Mapping coefficient. The value to be configured must be requested at local sales. Applied immediately
Unit	-
Index	0x2459
Subindex	2
Type	DT_F32
Default value	1.1142362
Range	...

Magnetizing current coefficient 1 [2459-3]

Name	**Magnetizing current coefficient 1 [2459-3]**
Description	Mapping coefficient. The value to be configured must be requested at local sales. Applied immediately
Unit	-
Index	0x2459
Subindex	3
Type	DT_F32
Default value	-0.00479468
Range	...

Magnetizing current coefficient 2 [2459-4]

Name	**Magnetizing current coefficient 2 [2459-4]**
Description	Mapping coefficient. The value to be configured must be requested at local sales. Applied immediately
Unit	-
Index	0x2459
Subindex	4
Type	DT_F32
Default value	0.00000959
Range	...

13.11.3 Iq to flux (ACIM)

Contains parameters to define Iq to Flux (Function: Torque calculation). Parameters in this section are only used if ACIM motor type is defined.

Constant for Iq to flux [2500]

Name	**Constant for Iq to flux [2500]**
Description	Mapping coefficient. The value to be configured must be requested at local sales. Applied immediately
Unit	-
Index	0x2500
Subindex	0
Type	DT_F32
Default value	0
Range	...

Coefficient 0 for Iq to flux [2490-1]

Name	**Coefficient 0 for Iq to flux [2490-1]**
Description	Mapping coefficient. The value to be configured must be requested at local sales. Applied immediately
Unit	-
Index	0x2490
Subindex	1
Type	DT_F32
Default value	0.0103245
Range	...

Coefficient 1 for Iq to flux [2490-2]

Name	**Coefficient 1 for Iq to flux [2490-2]**
Description	Mapping coefficient. The value to be configured must be requested at local sales. Applied immediately
Unit	-
Index	0x2490
Subindex	2
Type	DT_F32
Default value	-0.0000636
Range	...

Coefficient 2 for Iq to flux [2490-3]

Name	**Coefficient 2 for Iq to flux [2490-3]**
Description	Mapping coefficient. The value to be configured must be requested at local sales. Applied immediately
Unit	-
Index	0x2490
Subindex	3
Type	DT_F32
Default value	0.000000139
Range	...

13.11.4 Switch BLDC to FOC

Contains parameters for the block commutation (BC) control. Parameters in this section are only used if Hall sensors are configured as position sensor type.

Applied immediately

Speed to switch from BLDC to FOC control [21C0]

Name	**Speed to switch from BLDC to FOC control [21C0]**
Description	Defines the speed value where FOC starts. If speed is greater than this value, motor control switches from BC to FOC. Applied immediately
Unit	rpm
Index	0x21c0
Subindex	0
Type	DT_F32
Default value	0.03
Range	...

Speed to switch from FOC to BLDC control [21C1]

Name	**Speed to switch from FOC to BLDC control [21C1]**
Description	Defines the speed value where BC control starts. If speed is less than this value, motor control switches from FOC to BC. Applied immediately
Unit	rpm
Index	0x21c1
Subindex	0
Type	DT_F32
Default value	0.025
Range	...

13.12 Current control

Contains parameters for the current control settings

Applied immediately

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Maximum current difference [2146]

Name	**Maximum current difference [2146]**
Description	Defines the maximum current difference allowed between the reference current and the actual current. The maximum difference is verified for Id and Iq currents (Maximum Current difference = IqRef - Iq resp. Maximum Current difference = IdRef - Id). If the actual difference is greater than the value defined in this parameter a system error 2 will be generated. Large differences may occure if current controllers are not tuned correcly (i.e. if they overshoot or are too slow). Applied immediately
Unit	APeak
Index	0x2146
Subindex	0
Type	DT_F32
Default value	20
Range	...

Iq filter constant [217D]

Name	**Iq filter constant [217D]**
Description	Filter constant for acutal Iq filtering Applied at start-up (reset needed)
Unit	s
Index	0x217d
Subindex	0
Type	DT_F32
Default value	0.005
Range	...

Id filter constant [217E]

Name	**Id filter constant [217E]**
Description	Filter constant for actual Id filtering.n Applied at start-up (reset needed)
Unit	s
Index	0x217e
Subindex	0
Type	DT_F32
Default value	0.005
Range	...

13.12.1 Iq current control

Contains parameters for q-axis current control.

Configuration Iq current control [2190]

Name	**Configuration Iq current control [2190]**
Description	Defines options for the q-axis current controller. 0000 0001: enable non linear gain Applied at start-up (reset needed)
Unit	-
Index	0x2190
Subindex	0
Type	DT_U32
Default value	0
Range	...

Gain Kp Iq current control [2134]

Name	**Gain Kp Iq current control [2134]**
Description	Gain Kp of q-axis current regulator. Applied at start-up (reset needed)
Unit	p.u.
Index	0x2134
Subindex	0
Type	DT_F32
Default value	0.0012
Range	0 ... 1

Time constant Tn Iq current control [2135]

Name	**Time constant Tn Iq current control [2135]**
Description	Tn value of q-axis current regulator. Applied at start-up (reset needed)
Unit	s
Index	0x2135
Subindex	0
Type	DT_F32
Default value	0.00006
Range	...

Max output Iq current control [2137]

Name	**Max output Iq current control [2137]**
Description	Maximum output limit of q-axis current regulator. Applied at start-up (reset needed)
Unit	p.u.
Index	0x2137
Subindex	0
Type	DT_F32
Default value	0.97
Range	0 ... 1

Non linear gain corner current Kp (Iq) [2191]

Name	**Non linear gain corner current Kp (Iq) [2191]**
Description	Defines the corner point current for the Kp factor. Below this value Kp factor will decrease linear (Kp factor = (1.0 – actual current * Non linear gain Kp slope). Above this current value, the Kp factor will remain constant (Kp factor = 1.0 - Non linear gain corner current Kp * Non linear gain Kp slope). Applied at start-up (reset needed)
Unit	p.u.
Index	0x2191
Subindex	0
Type	DT_F32
Default value	0
Range	...

Non linear gain Kp slope (Iq) [2192]

Name	**Non linear gain Kp slope (Iq) [2192]**
Description	Defines the slope for the Kp factor to calculate Kp for a specific operating point. Applied at start-up (reset needed)
Unit	p.u.
Index	0x2192
Subindex	0
Type	DT_F32
Default value	1
Range	...

Non linear gain corner current Tn (Iq) [2193]

Name	**Non linear gain corner current Tn (Iq) [2193]**
Description	Defines the corner point current for the Tn factor. Below this value Tn factor will decrease linear (Tn factor = (1.0 – actual current * Non linear gain Tn slope). Above this current value, the Tn factor will remain constant (Tn factor = 1.0 - Non linear gain corner current Tn * Non linear gain Tn slope). Applied at start-up (reset needed)
Unit	p.u.
Index	0x2193
Subindex	0
Type	DT_F32
Default value	0
Range	...

Non linear gain Tn slope (Iq) [2194]

Name	**Non linear gain Tn slope (Iq) [2194]**
Description	Defines the slope for the Tn factor to calculate Tn for a specific operating point. Applied at start-up (reset needed)
Unit	p.u.
Index	0x2194
Subindex	0
Type	DT_F32
Default value	1
Range	...

13.12.2 Id current control

Contains parameters for d-axis current control.

Configuration Id current control [2195]

Name	Configuration Id current control [2195]
Description	Defines options for the q-axis current controller. 0000 0001: enable non linear gain Applied at start-up (reset needed)
Unit	-
Index	0x2195
Subindex	0
Type	DT_U32
Default value	0
Range	...

Gain Kp Id current control [2138]

Name	Gain Kp Id current control [2138]
Description	Gain Kp of d-axis current regulator Applied at start-up (reset needed)
Unit	p.u.
Index	0x2138
Subindex	0
Type	DT_F32
Default value	0.004
Range	0 ... 1

Time constant Tn Id current control [2139]

Name	Time constant Tn Id current control [2139]
Description	Tn factor of d-axis current regulator Applied at start-up (reset needed)
Unit	s
Index	0x2139
Subindex	0
Type	DT_F32
Default value	0.0001
Range	...

Max output Id current control [213B]

Name	**Max output Id current control [213B]**
Description	Maximum output limit of d-axis current regulator Applied at start-up (reset needed)
Unit	p.u.
Index	0x213B
Subindex	0
Type	DT_F32
Default value	0.97
Range	0 ... 1

Non linear gain corner current Kp (Id) [2196]

Name	**Non linear gain corner current Kp (Id) [2196]**
Description	Defines the corner point current for the Kp factor. Below this value Kp factor will decrease linear (Kp factor = (1.0 – actual current * Non linear gain Kp slope). Above this current value, the Kp factor will remain constant (Kp factor = 1.0 - Non linear gain corner current Kp * Non linear gain Kp slope). Applied at start-up (reset needed)
Unit	p.u.
Index	0x2196
Subindex	0
Type	DT_F32
Default value	0
Range	...

Non linear gain Kp slope (Id) [2197]

Name	**Non linear gain Kp slope (Id) [2197]**
Description	Defines the slope for the Kp factor to calculate Kp for a specific operating point. Applied at start-up (reset needed)
Unit	p.u.
Index	0x2197
Subindex	0
Type	DT_F32
Default value	1
Range	...

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Non linear gain corner current Tn (Id) [2198]

Name	**Non linear gain corner current Tn (Id) [2198]**
Description	Defines the corner point current for the Tn factor. Below this value Tn factor will decrease linear (Tn factor = (1.0 – actual current * Non linear gain Tn slope). Above this current value, the Tn factor will remain constant (Tn factor = 1.0 - Non linear gain corner current Tn * Non linear gain Tn slope). Applied at start-up (reset needed)
Unit	p.u.
Index	0x2198
Subindex	0
Type	DT_F32
Default value	0
Range	...

Non linear gain Tn slope (Id) [2199]

Name	**Non linear gain Tn slope (Id) [2199]**
Description	Defines the slope for the Tn factor to calculate Tn for a specific operating point. Applied at start-up (reset needed)
Unit	p.u.
Index	0x2199
Subindex	0
Type	DT_F32
Default value	1
Range	...

13.12.3 BLDC current control

Contains parameters for the current control settings for BLDC. Parameters in this section are only used if BLDC motor type is defined.

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Gain K (BLDC) [2130]

Name	Gain K (BLDC) [2130]
Description	Kp gain of current control of the BLDC motor. Applied immediately
Unit	p.u.
Index	0x2130
Subindex	0
Type	DT_F32
Default value	0.1
Range	0 ... 1

Time constant Tn (BLDC) [2131]

Name	Time constant Tn (BLDC) [2131]
Description	Time constant Tn of current control of the BLDC motor. Applied immediately
Unit	s
Index	0x2131
Subindex	0
Type	DT_F32
Default value	0.01
Range	...

Max output of Current regulator (BLDC) [2132]

Name	Max output of Current regulator (BLDC) [2132]
Description	Defines the maximum output limit of the BC-Current regulator. Applied immediately
Unit	p.u.
Index	0x2132
Subindex	0
Type	DT_F32
Default value	0.97
Range	...

13.13 Field weakening

Field weakening settings

Udq absolute vector maximum length [215F]

Name	**Udq absolute vector maximum length [215F]**
Description	Defines the maximum absolute value for the Udq voltage. If Udq reaches this limit the integral part of the PI regulator will be held on the last value. Applied immediately
Unit	p.u.
Index	0x215F
Subindex	0
Type	DT_F32
Default value	0.97000003
Range	...

KFact FW control limit 1 [214C]

Name	**KFact FW control limit 1 [214C]**
Description	PSM/IPMSM: If the length of Udq reference length filtered is greater than Udq absolute vector length1, the field weakening control starts. This parameter defines the slope with which Id will be generated. ACIM If the length of Udq reference length filtered is greater than Voltage limit3, the field weakening Control starts. This parameter defines the slope with which Iq will be reduced. Applied immediately
Unit	-
Index	0x214C
Subindex	0
Type	DT_F32
Default value	5
Range	...

KFact FW control limit 2 [2163]

Name	**KFact FW control limit 2 [2163]**
Description	PSM/IPMSM: If the length of Udq reference length filtered is greater than Udq absolute vector length2, the field weakening control changes the slope value to this parameter. Thereby the controller will be faster and Id will be generated faster. ACIM If the length of Udq reference length filtered is greater than Udq absolute vector maximum length, the field weakening changes the slope value to this parameter. This parameter defines the slope with which Iq will be reduced Applied immediately
Unit	-
Index	0x2163
Subindex	0
Type	DT_F32
Default value	40
Range	...

13.13.1 IPM / PSM

Contains IPM/PSM specific parameters for field weakening. Parameters in this section are only used if IPM or PSM motor type is defined.

Maximum absolute value of current (FW) [2142]

Name	**Maximum absolute value of current (FW) [2142]**
Description	Defines the maximum absolute value of current. Applied at start-up (reset needed)
Unit	Apeak
Index	0x2142
Subindex	0
Type	DT_F32
Default value	707
Range	...

Udq absolute vector length 1 (FW) [214B]

Name	**Udq absolute vector length 1 (FW) [214B]**
Description	If the length of Udq reference length filtered is greater than this parameter, the field weakening control starts. The KFact for FW Control Limit 1 parameter defines the slope with which Id is generated. Applied immediately
Unit	p.u.
Index	0x214B
Subindex	0
Type	DT_F32
Default value	0.92000002
Range	...

Udq absolute vector length 2 (FW) [2162]

Name	**Udq absolute vector length 2 (FW) [2162]**
Description	If Id is not fast enough generated and the Udq is reaching this value the slope with which Id is generated is changed to the parameter KFact for FW Control Limit 2. Applied immediately
Unit	p.u.
Index	0x2162
Subindex	0
Type	DT_F32
Default value	0.94
Range	...

Maximum value for Id (FW) [214D]

Name	Maximum value for Id (FW) [214D]
Description	Defines the maximum value of Id (p.u. of the maximum absolute current), which can be generated. Applied at start-up (reset needed)
Unit	p.u.
Index	0x214D
Subindex	0
Type	DT_F32
Default value	0.94999999
Range	...

D-Factor for Iq limitation in f(UdqAbs) [2160]

Name	D-Factor for Iq limitation in f(UdqAbs) [2160]
Description	D-Factor for Iq limitation in function of Udq absolute vector. Applied immediately
Unit	p.u.
Index	0x2160
Subindex	0
Type	DT_F32
Default value	0.002
Range	...

Start Iq limitation in f(UdqAbs) [2161]

Name	Start Iq limitation in f(UdqAbs) [2161]
Description	If Udq Absolute Vector reaches this value Iq will be limited. The Iq limitation is in function of Udq Absolute Vector for D-Part. Applied immediately
Unit	p.u.
Index	0x2161
Subindex	0
Type	DT_F32
Default value	0.72000003
Range	...

Minimum speed for generating Id [216B]

Name	**Minimum speed for generating Id [216B]**
Description	Defines the minimal speed at which Id will be generated. With decreasing DC Link voltage, QUASAR scales up speed to define the operating point of the machine. Therefore the field weakening will start at lower speeds. This parameter is to avoid high Id currents at low DC link voltage when speed is low. The parameter should be set below the field weakeing point for to lowest expected DC Link voltage in normal operation. Applied immediately
Unit	rpm
Index	0x216b
Subindex	0
Type	DT_F32
Default value	500
Range	...

13.13.2 ACIM

Contains ACIM specific parameters for field weakening.

KFact FW control limit Id 1 [2494]

Name	**KFact FW control limit Id 1 [2494]**
Description	If the length of Udq reference length filtered is greater than voltage limit 1, the field weakening control starts. This parameter defines the slope with which Id will be reduced. Applied immediately
Unit	-
Index	0x2494
Subindex	0
Type	DT_F32
Default value	5
Range	...

KFact FW control limit Id 2 [2505]

Name	KFact FW control limit Id 2 [2505]
Description	If the length ofUdq reference length filtered is greater than voltage limit 2, the field weakening control changes the slope value to this parameter. Thereby the controller will be faster and Id will be reduced faster. Applied immediately
Unit	-
Index	0x2505
Subindex	0
Type	DT_F32
Default value	40
Range	...

Voltage limit 1 [2495]

Name	Voltage limit 1 [2495]
Description	If the length of Udq reference length filtered is greater than this parameter, the field weakening control starts. The KFact FW control limit 1 parameter defines the slope with which Id is reduced. Applied when PWM enabled
Unit	p.u.
Index	0x2495
Subindex	0
Type	DT_F32
Default value	0.89999998
Range	...

Voltage limit 2 [2496]

Name	Voltage limit 2 [2496]
Description	If Id is not fast enough reduced and the Udq reference length filtered is reaching this value the slope with which Id is reduced is changed to the parameter KFact FW control limit 2.
Unit	p.u.
Index	0x2496
Subindex	0
Type	DT_F32
Default value	0.92000002
Range	...

Voltage limit 3 [2497]

Name	**Voltage limit 3 [2497]**
Description	If Id is not fast enough reduced and the Udq reference length filtered is reaching this iq current is also be reduced. The slope is defined Kfact FW control limit 1. Applied when PWM enabled
Unit	p.u.
Index	0x2497
Subindex	0
Type	DT_F32
Default value	0.95999998
Range	...

13.14 Dead time compensation

Contains parameters for dead time compensation

Applied immediately

Dead time compensation [2147]

Name	**Dead time compensation [2147]**
Description	Defines the dead time which should be compensated. It specifies the p.u. of the dead time to the switching time. Example: If the switches have a dead time of 3 us and the switching time is 30 us then this parameter would be 0.1 p.u. Applied immediately
Unit	-
Index	0x2147
Subindex	0
Type	DT_F32
Default value	0.045
Range	...

Dead time minimal current [2148]

Name	**Dead time minimal current [2148]**
Description	Defines the minimal phase current amplitude where dead time compensation will be calculated. If the current is below this value dead time compensation is turned off. Applied immediately
Unit	Apeak
Index	0x2148
Subindex	0
Type	DT_F32
Default value	0.01
Range	...

Dead time slope [2149]

Name	**Dead time slope [2149]**
Description	Defines the slope with which the dead time compensation is done. Applied immediately
Unit	p.u.
Index	0x2149
Subindex	0
Type	DT_F32
Default value	0.001
Range	...

13.15 Speed control

Contains parameters for speed control. Parameters in this section are only used if speed control is used.

Applied at start-up (reset needed)

13.15.1 Set point factor and offset [216E]

Scaling factor and offset for speed set point. Will also be applied to actual values read

Set point factor [216E-1]

Name	**Set point factor [216E-1]**
Description	Speed set point factor. The set point given is transformed in this manner: SetPointApplied = SetPointGiven * SetPointFactor + SetPointOffset
Unit	-
Index	0x216E
Subindex	1
Type	DT_F32
Default value	
Range	...

Set point offset [216E-2]

Name	**Set point offset [216E-2]**
Description	Speed set offset. The set point given is transformed in this manner: SetPointApplied = SetPointGiven * SetPointFactor + SetPointOffset
Unit	rpm
Index	0x216E
Subindex	2
Type	DT_F32
Default value	
Range	...

Reference speed filter [2126]

Name	**Reference speed filter [2126]**
Description	This parameter is used to set the speed filter time constant. Applied at start-up (reset needed)
Unit	s
Index	0x2126
Subindex	0
Type	DT_F32
Default value	0.000125
Range	...

Gain Kp of speed regulator [213C]

Name	**Gain Kp of speed regulator [213C]**
Description	Defines the Kp-gain of the speed regulator. Applied at start-up (reset needed)
Unit	p.u.
Index	0x213C
Subindex	0
Type	DT_F32
Default value	0.001
Range	0 ... 1

Gain Tn of speed regulator [213D]

Name	**Gain Tn of speed regulator [213D]**
Description	Defines the Tn factor of the speed regulator. Applied at start-up (reset needed)
Unit	s
Index	0x213D
Subindex	0
Type	DT_F32
Default value	0.0000002
Range	...

Maximum torque in speed mode [213E]

Name	**Maximum torque in speed mode [213E]**
Description	Defines the abolute maximum torque limit of speed regulator. Higher limits requested over the RxPDO 1 or 2 will be limited. Applied at start-up (reset needed)
Unit	p.u.
Index	0x213E
Subindex	0
Type	DT_F32
Default value	1
Range	...

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Minimum torque in speed mode [213F]

Name	**Minimum torque in speed mode [213F]**
Description	Defines the abolute minimum torque limit of speed regulator. Lower limits requested over the RxPDO 1 or 2 will be limited. Applied at start-up (reset needed)
Unit	p.u.
Index	0x213F
Subindex	0
Type	DT_F32
Default value	1
Range	...

13.16 CANOpen

Contains parameters for the CANOpen communication protocol. After changing these parameters the settings of the connecting device must also be adapted accordingly.

Node ID [20F3]

Name	**Node ID [20F3]**
Description	Defines the SKAIS node ID. It defines the address of the inverter on the CAN bus. The second node in dual systems will use this node ID incremented by one Applied at start-up (reset needed)
Unit	-
Index	0x20F3
Subindex	0
Type	DT_U8
Default value	122
Range	0 ... 127

Bitrate [20F1]

Name	**Bitrate [20F1]**
Description	Defines the bit rate of the CAN bus. The following rates are defined: 0: deactivated 1: 10 kBit/s 2: 20 kBit/s 3: 50 kBit/s 4: 100 kBit/s 5: 125 kBit/s 6: 250 kBit/s 7: 500 kBit/s 8: 800 kBit/s 9: 1 MBit/s Applied at start-up (reset needed)
Unit	-
Index	0x20F1
Subindex	0
Type	DT_U8
Default value	6
Range	1 ... 9

COB ID SYNC message [1005]

Name	**COB ID SYNC message [1005]**
Description	For each communication object exists an individual COB-ID (Communication Object Identifier) in the network, this ID allows prioritization of messages in case of a transmission collision. Set this to 40000080 to enable the sync producing (bit 30 must be 1 for sync producer) Applied at start-up (reset needed)
Unit	-
Index	0x1005
Subindex	0
Type	DT_U32
Default value	128
Range	...

Communication cycle period [1006]

Name	**Communication cycle period [1006]**
Description	The communication cycle period defines the interval in which synchronization objects are sent. Applied at start-up (reset needed)
Unit	us
Index	0x1006
Subindex	0
Type	DT_U32
Default value	250000
Range	...

Guard time [100C]

Name	**Guard time [100C]**
Description	Defines guard time in ms for node guarding. The time used for node guarding is: Time = Guard time * Life time factor Applied immediately
Unit	ms
Index	0x100C
Subindex	0
Type	DT_U16
Default value	300
Range	...

Scope node ID [20F4]

Name	**Scope node ID [20F4]**
Description	Defines CANOpen node ID used for Q-Control scope. The second node in dual systems will use this node ID incremented by one. The scope node ID must be different to the normal inverter node ID. Applied at start-up (reset needed)
Unit	-
Index	0x20F4
Subindex	0
Type	DT_U8
Default value	126
Range	0 ... 127

Delay between scope data [20F5]

Name	**Delay between scope data [20F5]**
Description	Defines the delay between scope data update. Set a delay between SDO upload. Gives a lower priory CAN message a chance to be sent.
Unit	ms
Index	0x20F5
Subindex	0
Type	DT_U16
Default value	200
Range	...

13.16.1 PDO data filters

Defines filters for actual values sent through PDOs

Iq display filter constant [217F]

Name	**Iq display filter constant [217F]**
Description	Filter constant for filtered actual value of Iq sent in PDO. Applied at start-up (reset needed)
Unit	s
Index	0x217f
Subindex	0
Type	DT_F32
Default value	0.01
Range	...

Id display filter constant [2180]

Name	**Id display filter constant [2180]**
Description	Filter constant for filtered actual value of Id sent in PDO. Applied at start-up (reset needed)
Unit	s
Index	0x2180
Subindex	0
Type	DT_F32
Default value	0.01
Range	...

Uq filter constant [2181]

Name	**Uq filter constant [2181]**
Description	Filter constant for filtered actual value of Uq sent in PDO. Applied at start-up (reset needed)
Unit	s
Index	0x2181
Subindex	0
Type	DT_F32
Default value	0.005
Range	...

Ud filter constant [2182]

Name	**Ud filter constant [2182]**
Description	Filter constant for filtered actual value of Ud sent in PDO. Applied at start-up (reset needed)
Unit	s
Index	0x2182
Subindex	0
Type	DT_F32
Default value	0.005
Range	...

13.16.2 TXPDO 1 [1800]

Contains parameters for TXPDO1 messages

Transmission type [1800-2]

Name	**Transmission type [1800-2]**
Description	Defines the transmission type for TXPDO1 Synchronous (transmission types 0-240 and 252) means that the transmission of the PDO shall be related to the SYNC object. Preferably the devices use the SYNC as a trigger to output or actuate based on the previous synchronous Receive PDO respectively to update the data transmitted at the following synchronous Transmit PDO. Asynchronous TPDOs are transmitted without any relation to a SYNC. A transmission type of zero means that the message shall be transmitted synchronously with the SYNC object but not periodically. For more information see the protocol description or check CANOpen specification CiA 301.
Unit	-
Index	0x1800
Subindex	2
Type	DT_U8
Default value	1
Range	...

Inhibit time [1800-3]

Name	**Inhibit time [1800-3]**
Description	To guarantee that no starvation on the network occurs for data objects with low priorities, data objects can be assigned an inhibit time. The inhibit-time of data object defines the minimum time that has to elapse between two consecutive invocations of a transmission service for that data object. Inhibit-times can be assigned by the application. This time is a minimum interval for PDO 1 transmission. The value is defined as multiple of 100us. It is not allowed to change the value while the PDO 1 exists.
Unit	ms
Index	0x1800
Subindex	3
Type	DT_U16
Default value	1050
Range	...

13.16.3 TXPDO 2 [1801]

Contains parameters for TXPDOs messages

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Transmission type [1801-2]

Name	**Transmission type [1801-2]**
Description	Defines the transmission type for TXPDO2 Synchronous (transmission types 0-240 and 252) means that the transmission of the PDO shall be related to the SYNC object. Preferably the devices use the SYNC as a trigger to output or actuate based on the previous synchronous Receive PDO respectively to update the data transmitted at the following synchronous Transmit PDO. Asynchronous TPDOs are transmitted without any relation to a SYNC. A transmission type of zero means that the message shall be transmitted synchronously with the SYNC object but not periodically. For more information see the protocol description or check CANOpen specification CiA 301.
Unit	-
Index	0x1801
Subindex	2
Type	DT_U8
Default value	1
Range	...

Inhibit time [1801-3]

Name	**Inhibit time [1801-3]**
Description	To guarantee that no starvation on the network occurs for data objects with low priorities, data objects can be assigned an inhibit time. The inhibit-time of data object defines the minimum time that has to elapse between two consecutive invocations of a transmission service for that data object. Inhibit-times can be assigned by the application. This time is a minimum interval for PDO 2 transmission. The value is defined as multiple of 100us. It is not allowed to change the value while the PDO 2 exists.
Unit	ms
Index	0x1801
Subindex	3
Type	DT_U16
Default value	4440
Range	...

13.16.4 TXPDO 3 [1802]

Contains parameters for TXPDO3 messages

Transmission type [1802-2]

Name	**Transmission type [1802-2]**
Description	Defines the transmission type for TXPDO3 Synchronous (transmission types 0-240 and 252) means that the transmission of the PDO shall be related to the SYNC object. Preferably the devices use the SYNC as a trigger to output or actuate based on the previous synchronous Receive PDO respectively to update the data transmitted at the following synchronous Transmit PDO. Asynchronous TPDOs are transmitted without any relation to a SYNC. A transmission type of zero means that the message shall be transmitted synchronously with the SYNC object but not periodically. For more information see the protocol description or check CANOpen specification CiA 301.
Unit	-
Index	0x1802
Subindex	2
Type	DT_U8
Default value	1
Range	...

Inhibit time [1802-3]

Name	**Inhibit time [1802-3]**
Description	To guarantee that no starvation on the network occurs for data objects with low priorities, data objects can be assigned an inhibit time. The inhibit-time of data object defines the minimum time that has to elapse between two consecutive invocations of a transmission service for that data object. Inhibit-times can be assigned by the application. This time is a minimum interval for PDO 3 transmission. The value is defined as multiple of 100us. It is not allowed to change the value while the PDO 3 exists.
Unit	ms
Index	0x1802
Subindex	3
Type	DT_U16
Default value	530
Range	...

13.16.5 TXPDO 4 [1803]

Contains parameters for TXPDO4 messages

Transmission type [1803-2]

Name	**Transmission type [1803-2]**
Description	Defines the transmission type for TXPDO4 Synchronous (transmission types 0-240 and 252) means that the transmission of the PDO shall be related to the SYNC object. Preferably the devices use the SYNC as a trigger to output or actuate based on the previous synchronous Receive PDO respectively to update the data transmitted at the following synchronous Transmit PDO. Asynchronous TPDOs are transmitted without any relation to a SYNC. A transmission type of zero means that the message shall be transmitted synchronously with the SYNC object but not periodically. For more information see the protocol description or check CANOpen specification CiA 301.
Unit	-
Index	0x1803
Subindex	2
Type	DT_U8
Default value	1
Range	...

Inhibit time [1803-3]

Name	**Inhibit time [1803-3]**
Description	To guarantee that no starvation on the network occurs for data objects with low priorities, data objects can be assigned an inhibit time. The inhibit-time of data object defines the minimum time that has to elapse between two consecutive invocations of a transmission service for that data object. Inhibit-times can be assigned by the application. This time is a minimum interval for PDO 4 transmission. The value is defined as multiple of 100us. It is not allowed to change the value while the PDO 4 exists.
Unit	ms
Index	0x1803
Subindex	3
Type	DT_U16
Default value	10530
Range	...

13.17 Tables

Contains parameters to adjust table lineartiy tolerance

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Epsilon X [2520]

Name	Epsilon X [2520]
Description	Defines maximum linearity tolerance between x-axis values due to the used floating type.
Unit	-
Index	0x2520
Subindex	0
Type	DT_U16
Default value	1
Range	1 ... 65536

Epsilon Y [2521]

Name	Epsilon Y [2521]
Description	Defines maximum linearity tolerance between y-axis values due to the used floating type.
Unit	-
Index	0x2521
Subindex	0
Type	DT_U16
Default value	1
Range	1 ... 65536

Name	
Description	
Unit	
Index	
Subindex	
Type	
Default value	
Range	...

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